NASA/SP—1999–7037/SUPPL400
May 14, 1999

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

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Typical Report Citation and Abstract

❶ 19970001126 NASA Langley Research Center, Hampton, VA USA
❷ **Water Tunnel Flow Visualization Study Through Poststall of 12 Novel Planform Shapes**
❸ Gatlin, Gregory M., NASA Langley Research Center, USA Neuhart, Dan H., Lockheed Engineering and Sciences Co., USA;
❹ Mar. 1996; 130p; In English
❺ Contract(s)/Grant(s): RTOP 505-68-70-04
❻ Report No(s): NASA-TM-4663; NAS 1.15:4663; L-17418; No Copyright; Avail: CASI; A07, Hardcopy; A02, Microfiche
❼ To determine the flow field characteristics of 12 planform geometries, a flow visualization investigation was conducted in the Langley 16- by 24-Inch Water Tunnel. Concepts studied included flat plate representations of diamond wings, twin bodies, double wings, cutout wing configurations, and serrated forebodies. The off-surface flow patterns were identified by injecting colored dyes from the model surface into the free-stream flow. These dyes generally were injected so that the localized vortical flow patterns were visualized. Photographs were obtained for angles of attack ranging from 10' to 50', and all investigations were conducted at a test section speed of 0.25 ft per sec. Results from the investigation indicate that the formation of strong vortices on highly swept forebodies can improve poststall lift characteristics; however, the asymmetric bursting of these vortices could produce substantial control problems. A wing cutout was found to significantly alter the position of the forebody vortex on the wing by shifting the vortex inboard. Serrated forebodies were found to effectively generate multiple vortices over the configuration. Vortices from 65' swept forebody serrations tended to roll together, while vortices from 40' swept serrations were more effective in generating additional lift caused by their more independent nature.
❽ Author
❾ *Water Tunnel Tests; Flow Visualization; Flow Distribution; Free Flow; Planforms; Wing Profiles; Aerodynamic Configurations*

Key

1. Document ID Number; Corporate Source
2. Title
3. Author(s) and Affiliation(s)
4. Publication Date
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01
AERONAUTICS

19990028427 Royal Aeronautical Society, London, UK

The Aeronautical Journal, Volume 101

Stollery, John L., Editor, Royal Aeronautical Society, UK; The Aeronautical Journal; November 1997; ISSN 0001-9240; 50p; In English; See also 19990028428 through 19990028433; Copyright; Avail: Issuing Activity (The Royal Aeronautical Society, 4 Hamilton Place, London WIV 0BQ), Hardcopy, Microfiche

This publication consists of the following articles: (1) An analytical model for ACSR approach to vibration reduction in helicopter rotor-flexible fuselage system; (2) Studies of vortex flaps for different sweepback angle delta wings; (3) Technical note: A note on the potential contribution of wing-body interference drag to the total drag of an aircraft; (4) Operational experience and test results in the adaptive test section of the DLR transonic tunnel; (5) On the use of large scale windtunnel models; (6) Efficient lift enhancement of a blunt edged delta wing.

CASI

Aerodynamics; Scale Models; Wind Tunnel Models; Aeronautical Engineering; Wind Tunnel Tests; Aerodynamic Characteristics; Aerodynamic Configurations

19990028619 Logistics Management Inst., McLean, VA USA

Aviation System Analysis Capability Executive Assistant Development

Roberts, Eileen, Logistics Management Inst., USA; Villani, James A., Logistics Management Inst., USA; Anderson, Kevin, Logistics Management Inst., USA; Book, Paul, Logistics Management Inst., USA; March 1999; 160p; In English

Contract(s)/Grant(s): NAS2-14361; RTOP 538-16-11-01

Report No.(s): NASA/CR-1999-209119; NS801S1; NAS 1.26:209119; No Copyright; Avail: CASI; A08, Hardcopy; A02, Microfiche

In this technical document, we describe the development of the Aviation System Analysis Capability (ASAC) Executive Assistant (EA) Proof of Concept (POC) and Beta version. We describe the genesis and role of the ASAC system, discuss the objectives of the ASAC system and provide an overview of components and models in the ASAC system, and describe the design process and the results of the ASAC EA POC and Beta system development. We also describe the evaluation process and results for applicable COTS software. The document has seven chapters, a bibliography, and two appendices.

Author

Aeronautics; Data Systems; Information Management; Information Transfer; Systems Analysis

19990031865 NASA Langley Research Center, Hampton,VA USA

Aeronautical Engineering: A Continuing Bibliography With Indexes, Supplement 398

Apr. 16, 1999; 61p; In English

Report No.(s): NASA/SP-1999-7037/SUPPL398; NAS 1.21:7037/SUPPL398; No Copyright; Avail: CASI; A04, Hardcopy; A01, Microfiche

This supplemental issue of Aeronautical Engineering lists reports, articles, and other documents recently announced in the NASA STI Database. The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles. Each entry in the publication consists of a standard bibliographic citation accompanied, in most cases, by an abstract.

The NASA CASI price code table, addresses of organizations, and document availability information are included before the abstract section. Two indexes - subject and author are included after the abstract section.
Derived from text
Aeronautical Engineering; Bibliographies; Abstracts

19990032102 Logistics Management Inst., McLean, VA USA
A Method for Forecasting the Commercial Air Traffic Schedule in the Future *Final Report*
Long, Dou, Logistics Management Inst., USA; Lee, David, Logistics Management Inst., USA; Gaier, Eric, Logistics Management Inst., USA; Johnson, Jesse, Logistics Management Inst., USA; Kostiuk, Peter, Logistics Management Inst., USA; January 1999; 90p; In English
Contract(s)/Grant(s): NAS2-14361; RTOP 538-16-11-01
Report No.(s): NASA/CR-1999-208987; NS806S1; NAS 1.26:208987; No Copyright; Avail: CASI; A05, Hardcopy; A01, Microfiche

This report presents an integrated set of models that forecasts air carriers' future operations when delays due to limited terminal-area capacity are considered. This report models the industry as a whole, avoiding unnecessary details of competition among the carriers. to develop the schedule outputs, we first present a model to forecast the unconstrained flight schedules in the future, based on the assumption of rational behavior of the carriers. Then we develop a method to modify the unconstrained schedules, accounting for effects of congestion due to limited NAS capacities. Our underlying assumption is that carriers will modify their operations to keep mean delays within certain limits. We estimate values for those limits from changes in planned block times reflected in the OAG. Our method for modifying schedules takes many means of reducing the delays into considerations, albeit some of them indirectly. The direct actions include depeaking, operating in off-hours, and reducing hub airports'operations. Indirect actions include using secondary airports, using larger aircraft, and selecting new hub airports, which, we assume, have already been modeled in the FAA's TAF. Users of our suite of models can substitute an alternative forecast for the TAF.
Author
Air Transportation; Schedules; Forecasting; Air Traffic

02
AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

19990028433 Texas A&M Univ., Aerospace Engineering Dept., College Station, TX USA
Efficient lift enhancement of a blunt edged delta wing
Traub, L. W., Texas A&M Univ., USA; The Aeronautical Journal; November 1997; Volume 101, No. 1009, pp. 439-445; In English; See also 19990028427
Report No.(s): Paper-2338; Copyright; Avail: Issuing Activity (The Royal Aeronautical Society, 4 Hamilton Place, London WIV 0BQ), Hardcopy, Microfiche

A windtunnel study was undertaken to determine the effectiveness of leading edge vortex plates in enhancing the lifting abilities of a blunt edged delta wing. In the investigation, vortex plates were attached to both the upper and lower surfaces of the leading edge. Various positions of the vortex plates with respect to the wing's leading edge were evaluated. The results indicate that a vortex plate located on the upper surface of the wing is capable of increasing lift so as to be comparable to a similar sharp edged wing, while reducing drag through some retained leading edge thrust. The increase in zero lift drag associated with vortex plate attachment tends to limit potential performance improvements. A vortex plate mounted on the lower wing surface decreased lift slightly compared to the blunt wing. However, drag was found to decrease markedly.
Author
Delta Wings; Drag Reduction; Leading Edges; Vortices; Zero Lift; Wind Tunnel Tests; Vortex Flaps; Leading Edge Flaps; Lift Augmentation

19990028449 Defence Science and Technology Organisation, Aeronautical and Maritime Research Lab., Melbourne, Australia
Survey on the Aerodynamics of Battle-Damaged Combat Aircraft
Erm, Lincoln P.; Jun. 1998; 20p; In English
Report No.(s): AD-A360572; DSTO-GD-0184; DODA-AR-010-563; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

A literature survey on the aerodynamics of battle-damaged combat aircraft is presented in this report. The survey considers experimental investigations carried out in wind tunnels using either scaled or full-sized models of complete aircraft or components of aircraft that have either simulated damage or actual gunfire damage. The survey could assist in the planning of a possible experimental program at AMRL to obtain aerodynamic data for battle-damaged aircraft. The data could be used in modelling the flight-dynamic behaviour of damaged aircraft.
DTIC
Fighter Aircraft; Damage; Aerodynamics; Flight Characteristics

19990028620 Allison Engine Co., Indianapolis, IN USA
ADPAC v1.0: User's Manual ***Final Report***
Hall, Edward J., Allison Engine Co., USA; Heidegger, Nathan J., Allison Engine Co., USA; Delaney, Robert A., Allison Engine Co., USA; February 1999; 268p; In English
Contract(s)/Grant(s): NAS3-27394; RTOP 538-03-11
Report No.(s): NASA/CR-1999-206600; E-11089; NAS 1.26:206600; No Copyright; Avail: CASI; A12, Hardcopy; A03, Microfiche

The overall objective of this study was to evaluate the effects of turbulence models in a 3-D numerical analysis on the wake prediction capability. The current version of the computer code resulting from this study is referred to as ADPAC v7 (Advanced Ducted Propfan Analysis Codes -Version 7). This report is intended to serve as a computer program user's manual for the ADPAC code used and modified under Task 15 of NASA Contract NAS3-27394. The ADPAC program is based on a flexible multiple-block and discretization scheme permitting coupled 2-D/3-D mesh block solutions with application to a wide variety of geometries. Aerodynamic calculations are based on a four-stage Runge-Kutta time-marching finite volume solution technique with added numerical dissipation. Steady flow predictions are accelerated by a multigrid procedure. Turbulence models now available in the ADPAC code are: a simple mixing-length model, the algebraic Baldwin-Lomax model with user defined coefficients, the one-equation Spalart-Allmaras model, and a two-equation k-R model. The consolidated ADPAC code is capable of executing in either a serial or parallel computing mode from a single source code.
Author
Applications Programs (Computers); User Manuals (Computer Programs); Prop-Fan Technology; Computational Fluid Dynamics; Turbulence Models; Computational Grids; Turbomachinery

19990031948 NASA Langley Research Center, Hampton, VA USA
Computational Test Cases for a Clipped Delta Wing with Pitching and Trailing-Edge Control Surface Oscillations
Bennett, Robert M., NASA Langley Research Center, USA; Walker, Charlotte E., Tennessee Univ., USA; March 1999; 90p; In English
Contract(s)/Grant(s): RTOP 522-31-81-03
Report No.(s): NASA/TM-1999-209104; L-17822; NAS 1.15:209104; No Copyright; Avail: CASI; A05, Hardcopy; A01, Microfiche

Computational test cases have been selected from the data set for a clipped delta wing with a six-percent-thick circular-arc airfoil section that was tested in the NASA Langley Transonic Dynamics Tunnel. The test cases include parametric variation of static angle of attack, pitching oscillation frequency, trailing-edge control surface oscillation frequency, and Mach numbers from subsonic to low supersonic values. Tables and plots of the measured pressures are presented for each case. This report provides an early release of test cases that have been proposed for a document that supplements the cases presented in AGARD Report 702.
Author
Computational Fluid Dynamics; Delta Wings; Airfoil Profiles; Control Surfaces; Pitch (Inclination); Wind Tunnel Tests; Unsteady Aerodynamics; Transonic Flow; Computerized Simulation

19990032290 NASA Ames Research Center, Moffett Field, CA USA
Selection of Slow and Fast Variables in the Three-Dimensional Flight Dynamics
Ardema, M., NASA Ames Research Center, USA; Rajan, N., Stanford Univ., USA; 19840608; 5p; In English; American Control Conference, 6-8 Jun. 1984, USA; Copyright; Avail: Issuing Activity, Hardcopy, Microfiche

A transformation from the altitude and velocity state variables of three-dimensional flight mechanics to a new set of more desirable variables is found. The new variables provide a greater time-scale separation, decrease system coupling, and give better estimates of the fast-variable values along the reduced solution. One of the new variables is the often-used specific energy, whereas

the other variable changes along a given trajectory, depending on the nature of the local reduced solution. Numerical examples are included.
Author
Flight Mechanics; Aerodynamics; Estimates

19990032430 Naval Surface Warfare Center, Carderock Div., Bethesda, MD USA
Force and Moment Calculations of an Appendage Using the Reynolds Averaged Navier-Stokes Equations *Final Report*
Gorski, Joseph J.; Buley, Gregory M.; Jul. 1998; 29p; In English
Report No.(s): AD-A360510; CRDKNSWC/HD-1362-06; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

This report describes efforts to compute forces and moments about an appendage using the Reynolds averaged Navier-Stokes (RANS) equations. All computations presented are done with the Mississippi State University code UNCLE. Calculations are performed for a two-dimensional NACA 0012 airfoil and a three-dimensional NACA 0015 low-aspect ratio appendage mounted on a ground board. Results are presented for both forward and reverse flow conditions.
DTIC
Force; Appendages; Low Aspect Ratio; Method of Moments; Computation

03
AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

19990028558 Federal Aviation Administration, Fire Safety Section, Atlantic City, NJ USA
Full-Scale Test Evaluation of Aircraft Fuel Fire Burnthrough Resistance Improvements *Final Report*
Marker, Timothy R.; Jan. 1999; 41p; In English
Report No.(s): AD-A360550; DOT/FAA/AR-98/52; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

This report summarizes the research and full-scale tests undertaken by the Federal Aviation Administration (FAA) to evaluate the fuselage burnthrough resistance of transport category aircraft that are exposed to large postcrash fuel fires. Twenty-eight full-scale tests were conducted in a reusable fuselage test rig to determine the effectiveness of thermal-acoustical insulation improvements in preventing or delaying fuselage burnthrough. The testing showed that the method of attaching the insulation to the fuselage structure had a critical effect on the effectiveness of the insulation material. In addition, the composition of the insulation bagging material, normally a thermoplastic film, was also shown to be an important factor. A number of fiberglass insulation modifications and new insulation materials were shown to be effective in varying degrees. For example, a heat-treated, oxidized polyacrylonitrile fiber (OPF) encased in a polyimide bagging material prevented burnthrough for over 8 minutes. When contrasted with current insulation materials, which were shown to fail in as little as 2 minutes, effective fire barriers such as the OPF insulation offer the potential of saving lives during a postcrash fire accident in which the fuselage remains intact.
DTIC
Aircraft Fuels; Flammability; Full Scale Tests; Fuselages; Transport Aircraft; Fires

19990028662 Federal Aviation Administration, Washington, DC USA
Notices to Airmen: Domestic/International
Nov. 05, 1998; 188p; In English
Report No.(s): PB99-116568; No Copyright; Avail: CASI; A09, Hardcopy; A02, Microfiche

The following topics are discussed: Airway Notams; Airports, Facilities, and Procedural Notams; General FDC Notams; Part 95 Revisions to Minimum En Route IFR Altitudes and Changeover Points; International Notices to Airmen; and Graphic Notices.
NTIS
Air Navigation; Airports; Flight Paths; Air Traffic Control

19990032241 Federal Aviation Administration, Airport and Aircraft Safety Research and Development, Atlantic City, NJ USA
Mixed-Phase Icing Conditions: A Review *Final Report*
Riley, James T.; Dec. 1998; 45p; In English
Report No.(s): AD-A359346; DOT/FAA/AR-98-76; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

This report reviews publicly available evidence bearing upon possible safety hazards due to flight in mixed-phase conditions. Recent investigations with modern instrumentation suggest that these conditions are more frequent and widespread than had been realized. However, information characterizing these conditions which is suitable for addressing questions of aviation safety is very

limited. Facility simulation of mixed-phase conditions is difficult and well-controlled simulations have been done in very few facilities in the world. It is not known how well the various methods that have been used actually simulate the natural environment, nor with what degree of fidelity it needs to be simulated for the investigation of some safety questions. The limited data available from research flights does not indicate that there is any difference in performance effects caused by structural icing resulting from flight in mixed-phase cloud rather than in purely liquid supercooled cloud.
DTIC
Ice Formation; Aircraft Icing; Flight Safety

19990032378 Federal Aviation Administration, Airport and Aircraft Safety Research and Development, Atlantic City, NJ USA
Snow and Ice Particle Sizes and Mass Concentrations at Altitudes Up to 9 km (30,000 ft) ***Final Report***
Jeck, Richard K.; Aug. 1998; 93p; In English
Report No.(s): AD-A359349; AAR-421; DOT/FAA/AR-97/66; No Copyright; Avail: CASI; A05, Hardcopy; A01, Microfiche

About 7600 nautical miles (nm) (14,000 km) of select ice particle measurements over the USA have been compiled into a single, computerized database for use in characterizing ice crystal and snowflake (generally termed ice particle) size distributions and mass concentrations at flight altitudes. Data are from 50 research flights by six agencies in eight flight research projects using Particle Measuring Systems' one-dimensional (1-D) and two-dimensional (2-D) particle sizing probes. Primary recorded variables are average particle size distributions in the range 0.1 to 10 mm from each of 1625 microphysically uniform cloud intervals or other convenient distances in wintertime clouds, snowstorms, cirrus, and other high-altitude clouds. The findings are that, generally, the largest particles and the greatest concentrations of total ice particle mass (TIPM) are confined to altitudes below 20,000 ft (6 km). There, particles of 10 mm in maximum dimension and TIPM's up to about 3 g/cu m may be found. Above 20,000 ft, particles are smaller than 2 mm and TIPM's are less than 0.2 g/cu m in the cirrus and the upper reaches of deep winter storm clouds that are found at these levels. Exceptions are thunderstorm anvil clouds where 10 mm particles and TIPM's of at least 1 g/cu m can be found up to at least 30,000 ft (9 km). Anvil clouds and stratiform clouds associated with warm season mesoscale convective systems have provided some of the largest TIPM's, the greatest particle concentrations, and the largest particle sizes at high and mid altitudes, respectively. In contrast to supercooled cloud droplets where the largest liquid water (mass) concentrations are confined to short distances of 3 nm or less in convective clouds, the largest average TIPM's in glaciated clouds have been found in layer clouds over distances up to 30 nm.
DTIC
Ice Formation; Flight Safety; Cloud Physics; Aircraft Icing; Mesoscale Phenomena; Particle Mass; Snow

05
AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

19990028428 California Univ., Mechanical and Aerospace Engineering Dept., Los Angeles, CA USA
An analytical model for ACSR approach to vibration reduction in a helicopter rotor-flexible fuselage system
Chiu, T., California Univ., USA; Friedmann, P. P., California Univ., USA; The Aeronautical Journal; November 1997; Volume 101, No. 1009, pp. 399-408; In English; 22nd; European Rotocraft Forum, Sep. 1996, Brighton, UK; See also 19990028427
Contract(s)/Grant(s): DAAH04-93-G-0004
Report No.(s): Paper-2256; Copyright; Avail: Issuing Activity (The Royal Aeronautical Society, 4 Hamilton Place, London WIV 0BQ), Hardcopy, Microfiche

This paper describes the development of a coupled rotor-flexible fuselage model which is suitable for simulating vibration reduction based on the active control of structural response (ACSR) approach. The rotor is an N(sub b)-bladed aeroelastic model, with coupled flap-lag-torsional dynamics for each blade. Moderate blade deflections are included, together with complete coupling between rotor and fuselage dynamics. This aeroelastic response model is combined with a control algorithm based on an internal model principle. The control scheme effectively reduces vibrations to 0.05g levels or lower, using reasonable actuator forces. The baseline vibration levels in the fuselage are relatively high. This is due to the lack of damping modelling in the fuselage. With the actuators engaged, the hub loads remain virtually unchanged and therefore this control approach has no influence on vehicle airworthiness.
Author
Active Control; Aeroelasticity; Rotor Dynamics; Vibration Damping; Rotor Aerodynamics; Mathematical Models; Dynamic Response; Actuators

19990028429 Tokyo Univ., Dept. of Aeronautics and Astronautics, Japan
Studies of vortex flaps for different sweepback angle delta wings
Rinoie, K., Tokyo Univ., Japan; The Aeronautical Journal; November 1997; Volume 101, No. 1009, pp. 409-416; In English; CEAS European Forum on High Lift and Separation Control, 1995, Bath, UK; See also 19990028427
Report No.(s): Paper-2271; Copyright; Avail: Issuing Activity (The Royal Aeronautical Society, 4 Hamilton Place, London WIV 0BQ), Hardcopy, Microfiche

Low speed windtunnel measurements were made on a 50 deg. delta wing with leading edge vortex flaps. Improvements in the lift/drag ratio were obtained by deflecting the leading edge vortex flap. Comparisons were made between the previously measured 60 and 70 deg. delta wing results and the present 50 deg. wing results. Improvements in the lift/drag ratio of the 50 deg. delta wing were attained over a wider lift coefficient range than for the 70 deg. delta wing. The highest lift/drag ratio for the 50 deg. delta wing is achieved when the flow attaches to the flap surface without any large area of separation. Estimations of the aerodynamic forces were also made using a quasi-vortex lattice method coupled with the leading edge suction analogy for the 50 deg., 60 deg. and 70 deg. delta wings. The results obtained from this analysis agree qualitatively with the experimental results.
Author
Delta Wings; Leading Edge Flaps; Lift Drag Ratio; Sweepback; Vortex Flaps; Angles (Geometry); Wind Tunnel Tests; Low Speed Stability

19990028430 Queen Mary and Westfield Coll., Dept. of Engineering, London, UK
A note on the potential contribution of wing-body interference drag to the total drag of an aircraft
Bernstein, L., Queen Mary and Westfield Coll., UK; The Aeronautical Journal; November 1997; Volume 101, No. 1009, pp. 417-420; In English; See also 19990028427
Report No.(s): Paper-2351; Copyright; Avail: Issuing Activity (The Royal Aeronautical Society, 4 Hamilton Place, London WIV 0BQ), Hardcopy, Microfiche

The implications of a rise in the pressure drag of a wing near its junction with a fuselage are examined. Based on some data measured for a swept-wing-plate junction, in which the wing was of NACA 0015-profile normal to its leading edge and swept back at 20 degrees, it is found that there is a potential penalty of order 1% of the total aircraft drag in the cruise condition.
Author
Aerodynamic Drag; Body-Wing Configurations; Fuselages; Interactional Aerodynamics; Pressure Drag; Swept Wings; Interference Drag

19990028444 Defence Science and Technology Organisation, Aeronautical and Maritime Research Lab., Melbourne, Australia
Synchronous Averaging of Helicopter Tail Rotor Gearbox Vibration: Phase Reference Considerations
Blunt, D. M.; Oct. 1998; 56p; In English
Report No.(s): AD-A360600; DSTO-TR-0739; DODA-AR-010-666; No Copyright; Avail: CASI; A04, Hardcopy; A01, Microfiche

Synchronous averaging requires an accurate phase reference (tachometer) signal. In helicopter transmissions, such a signal can usually be obtained or derived from an engine or main rotor gearbox accessory, but is not as readily available for the tail rotor gearbox. This report examines whether a separate tail rotor gearbox phase reference signal is necessary by investigating the relative jitter, due to dynamic tail drive shaft twist, between phase reference signals obtained from the main and tail rotor gearboxes in a S7OA-9 Black Hawk helicopter.
DTIC
Helicopter Tail Rotors; Structural Vibration; Helicopter Propeller Drive

19990028445 Defence Science and Technology Organisation, Aeronautical and Maritime Research Lab., Melbourne, Australia
Stress and Strain Estimation of Notches in Aircraft Structures
Jones, R.; Knapp, M.; Price, J.; Molent, L.; Oct. 1998; 31p; In English
Report No.(s): AD-A360599; DSTO-GD-0196; COE-SM-98-01; DODA-AR-010-652; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

To maintain the continued airworthiness of military aircraft it is essential that the fatigue behavior of components subjected to complex multi-axial stress conditions be both understood and predicted. This topic is extremely complex. Numerous fatigue failure criteria ranging from the purely empirical to the theoretical have been proposed. These criteria rely on the estimation of stress and strain at fatigue critical locations. This interim report focused on possible approaches which may be applicable to both

low and high-cycle fatigue regimes. It discusses the relative advantages of the Neuber and the Glinka methods for calculating localized notch strains as compared to the results from finite element analysis.
DTIC
Notches; Aircraft Reliability; Aircraft Structures; Axial Stress; Finite Element Method; Fatigue Life

19990028450 Defence Science and Technology Organisation, Aeronautical and Maritime Research Lab., Melbourne, Australia
The Yield Behaviour of a Structural Adhesive Under Complex Loading
Ignjatovic, Mladen; Chalkley, Peter; Wang, Chun; Sep. 1998; 41p; In English
Report No.(s): AD-A360569; DSTO-TR-0728; DODA-AR-010-646; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

Recent developments in bonded composite repair technology at the Aeronautical and Maritime Research Laboratory (AMRL) have been in the area of repairs to curved surfaces, e.g. the proposed repairs to the F/A-18 aileron hinge and the F/A-18 bulkhead crotch region. Bonded composite repairs to curved surfaces induce through-thickness stresses as well as shear stresses in the adhesive. The yield behaviour of AMRLs most common repair adhesive - FM73 - has not been investigated under such conditions of combined loading. Reported herein is a yield function for the repair adhesive FM73, based upon the Modified Drucker-Prager/Cap Plasticity model. This yield function was selected based on experiments on a test specimen subjected to a range of combined stress states. A finite element (FE) analysis of test specimen (Iosipescu test specimen modified for adhesives) was carried out to establish its validity for obtaining data.
DTIC
Airframes; Adhesive Bonding; Aircraft Maintenance; Bonded Joints; F-18 Aircraft; Load Distribution (Forces); Finite Element Method; Shear Stress

19990028567 NASA Lewis Research Center, Cleveland, OH USA
Comparison of cooler arrangements for the thermal management system of an atmospheric science remotely piloted vehicle
Maldonado, Jaime J., NASA Lewis Research Center, USA; Bents, David J., NASA Lewis Research Center, USA; JANNAF Airbreathing Propulsion Subcommittee Meeting; October 1997; Volume 1, pp. 89-98; In English; See also 19990028559; No Copyright; Avail: CPIA, 10630 Little Patuxent Pkwy., Suite 202, Columbia, MD 21044-3200 HC, Hardcopy, Microfiche

The design and comparison of two cooler arrangements for the thermal management system of a high altitude atmospheric science remotely piloted vehicle have been completed. The propulsion system of this vehicle consist of a triply turbocharged Rotax 912 delivering 80 HP at 80,000 ft. under hot-day conditions. The thermal management system needs to dissipate heat from the internal combustion engine, as well as the compression heat generated in the turbochargers. to predict the performance and estimate the weight of the thermal management system, a heat exchanger design and analysis tool called LACEX has been used. The intermediate cooling loop arrangement has the advantage of easier installation and packaging in the aircraft structure, but is heavier than the direct air-to-air arrangement. Likewise, the drag produced by the intermediate cooling loop arrangement is greater than the direct air-to-air arrangement. Considering the importance of minimizing weight and drag, the direct air-to-air system appears to be a better arrangement for this type of vehicle.
Author
Coolers; Heat Exchangers; High Altitude; Internal Combustion Engines; Remotely Piloted Vehicles; Systems Engineering; Temperature Control; Propulsion System Configurations

19990028762 NASA Langley Research Center, Hampton, VA USA
Active Vertical Tail Buffeting Alleviation on an F/A-18 Model in a Wind Tunnel
Moses, Robert W., NASA Langley Research Center, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 821-830; In English; See also 19990028721; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

A 1/6-scale F-18 wind-tunnel model was tested in the Transonic Dynamics Tunnel at the NASA Langley Research Center as part of the Actively Controlled Response of Buffet-Affected Tails (ACROBAT) program to assess the use of active controls in reducing vertical tail buffeting. The starboard vertical tail was equipped with an active rudder and other aerodynamic devices, and the port vertical tail was equipped with piezoelectric actuators. The tunnel conditions were atmospheric air at a dynamic pressure of 14 psf. by using single-input-single-output control laws at gains well below the physical limits of the control effectors, the power spectral density of the root strains at the frequency of the first bending mode of the vertical tail was reduced by as much as 60 percent up to angles of attack of 37 degrees. Root mean square (RMS) values of root strain were reduced by as much as 19

percent. Stability margins indicate that a constant gain setting in the control law may be used throughout the range of angle of attack tested.
Author
Active Control; Buffeting; Scale Models; SISO (Control Systems); Tail Assemblies; Wind Tunnel Models; Control Equipment; Power Spectra

19990028765 Interpacific Technology, Inc., Oakland, CA USA
Design of Visually Inspectable Fuselage Skin Repairs
Chen, P. C., Interpacific Technology, Inc., USA; Roderick, D. B., Interpacific Technology, Inc., USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 853-862; In English; See also 19990028721
Contract(s)/Grant(s): DTFA03-94-C-00005; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

A new approach which uses the concept of visually inspectable repairs has been employed to design fuselage skin repairs. A visually inspectable fuselage skin repair is one for which a crack emanating from the fastener hole with the largest fastener load in the skin is visually inspectable from the most accessible side of the skin, thus reducing the reliance on nondestructive inspection (NDI) techniques to detect cracks prior to catastrophic failure. This paper presents the guidelines used in designing visually inspectable repairs for fuselage skins with different damage configurations, i.e., skin with a circular hole, skin with a rectangular cutout, and skin with a crack. It discusses why a skin repair is or is not visually inspectable, how a nonvisually inspectable skin repair can be made visually inspectable, and what guidelines need to be followed to design a visually inspectable fuselage skin repair.
Author
Skin (Structural Member); Fuselages; Inspection; Visual Observation; Structural Analysis

19990032180 Sandia National Labs., FAA Airworthiness Assurance NDI Validation Center, Albuquerque, NM USA
Detection Reliability for Small Cracks Beneath Rivet Heads Using Eddy-Current Nondestructive Inspection Techniques *Final Report*
Spencer, Floyd W.; Dec. 1998; 55p; In English
Report No.(s): AD-A359396; DOT/FAA/AR-97/73; No Copyright; Avail: CASI; A04, Hardcopy; A01, Microfiche

Advanced inspection technology that is emerging from the laboratory is generally far superior to the less capable systems around which aircraft inspections are designed. In light of the very conservative nature of these inspection designs, it is apparent that today’s advanced technology is being employed at only a fraction of its full potential. In order to assess the full potential of advanced eddy-current inspection technology on representative aircraft applications, the FAA’s Airworthiness Assurance Nondestructive Inspection Validation Center (AANC) was tasked to assess the full capability of several advanced systems. The task involved inspections of several rivet skin splices-representative of actual aircraft structure-containing cracks ranging from 0.040-, 0.060-, and 0.080-inch standards, and thresholds were set to the lowest reasonable level for the particular system. The results demonstrated that some of the systems were able to reliably detect cracks as small as 0.040 inch with false call rates remained less than 1%.
DTIC
Nondestructive Tests; Rivets; Cracks; Inspection; Aircraft Maintenance

19990032205 Defence Science and Technology Organisation, Aeronautical and Maritime Research Lab., Melbourne Australia
Variational Bounds for the Equivalent Spring Constants for Bonded Repairs
Chalkley, Peter; Rose, L. R.; Sep. 1998; 41p; In English
Report No.(s): AD-A360611; DSTO-RR-0139; DODA-AR-010-644; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

Variational bounds, both upper and lower, are found for the equivalent spring constant of a double-strap joint which represents a sub-element of bonded repairs to cracked structure. Conservative estimates of the equivalent spring constant, needed for accurate design, are obtained from variational analyses of the joint. Estimates from various analytical models of varying level of approximation were obtained. Simpler expressions for the spring constant resulted from relaxing certain assumptions, however, the theoretical guarantee of a true upper or lower bound was lost Spring constant estimates were compared with finite element model results and so the fidelity of the variational bounds, specially for the simplified analyses, could be established. An improved formula is proposed for use in design procedures in RAAF C5033.
DTIC
Aircraft Maintenance; Mathematical Models; Bonded Joints; Attack Aircraft

19990032232 Department of Energy, Office of Financial Management and Controller, Washington, DC USA

Development of a biaxial test facility for structural evaluation of aircraft fuselage panels

Roach, D., Department of Energy, USA; Walkington, P., Department of Energy, USA; Rice, T., Department of Energy, USA; Mar. 31, 1998; 6p; In English; SEM Experimental and Applied Mechanics, 1998, USA

Report No.(s): DE98-004256; SAND-98-0696C; CONF-980627; No Copyright; Avail: Department of Energy Information Bridge, Microfiche

The number of commercial airframes exceeding twenty years of service continues to grow. An unavoidable by-product of aircraft use is that crack and corrosion flaws develop throughout the aircraft's skin and substructure elements. Economic barriers to the purchase of new aircraft have created an aging aircraft fleet and placed even greater demands on efficient and safe repair methods. Composite doublers, or repair patches, provide an innovative repair technique which can enhance the way aircraft are maintained. Instead of riveting multiple steel or aluminum plates to facilitate an aircraft repair, it is now possible to bond a single Boron-Epoxy composite doubler to the damaged structure. The composite doubler repair process produces both engineering and economic benefits. The FAA's Airworthiness Assurance Center at Sandia National Labs completed a project to introduce composite doubler repair technology to the commercial aircraft industry. This paper focuses on a specialized structural test facility which was developed to evaluate the performance of composite doublers on actual aircraft structure. The facility can subject an aircraft fuselage section to a combined load environment of pressure (hoop stress) and axial, or longitudinal, stress. The tests simulate maximum cabin pressure loads and use a computerized feedback system to maintain the proper ratio between hoop and axial loads. Through the use of this full-scale test facility it was possible to: (1) assess general composite doubler response in representative flight load scenarios, and (2) verify the design and analysis approaches as applied to an L-1011 door corner repair.

NTIS

Test Facilities; Composite Materials; Fabrication; Fuselages; Evaluation; Aircraft Structures; Commercial Aircraft

19990032410 Defence Science and Technology Organisation, Aeronautical and Maritime Research Lab., Melbourne Australia

Service History of the F-111 Wing Pivot Fitting Upper Surface Boron/Epoxy Doublers

Chalkley, Peter; Geddes, Rowan; Sep. 1998; 23p; In English

Report No.(s): AD-A360610; DSTO-TN-0168; DODA-AR-010-643; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

Several of the boron/epoxy doublers applied to upper surface of RAAF F-111C wing- pivot-fittings (WFFs) have disbonded. Based on RAAF records, a total of seven wings (out of forty to which doublers have been applied) have confirmed disbonds: A15-3, A15-5, A15-10, A15-14, A15-19, A15-20 and A15-284R. Most of the disbonds are forming in the smaller forward doubler (five confirmed) although three aft doublers have also disbonded. This report documents the service history of all doublers applied to RAAF F-111Cs. The current investigation suggests that disbonds in the boron/epoxy doublers on the upper surface of F-111 WFFs are forming within 1000 AFHRS service. However, infrequent inspections of the doublers make a precise determination difficult issues such as the use of external wing tanks on some aircraft (especially RF111C's), disbond initiation sites and below tolerance wing skin thicknesses are investigated.

DTIC

Aircraft Maintenance; Bonded Joints; Tilt Wing Aircraft; Services; Service Life; Boron-Epoxy Composites

07
AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and onboard auxiliary power plants for aircraft.

19990028488 Toledo Univ., OH USA

A Java-Enabled Interactive Graphical Gas Turbine Propulsion System Simulator

Reed, John A., Toledo Univ., USA; Afjeh, Abdollah A., Toledo Univ., USA; 1997; 9p; In English

Contract(s)/Grant(s): NAG3-1750

Report No.(s): AIAA Paper 97-0233; Copyright; Avail: Issuing Activity, Hardcopy, Microfiche

This paper describes a gas turbine simulation system which utilizes the newly developed Java language environment software system. The system provides an interactive graphical environment which allows the quick and efficient construction and analysis of arbitrary gas turbine propulsion systems. The simulation system couples a graphical user interface, developed using the Java Abstract Window Toolkit, and a transient, space- averaged, aero-thermodynamic gas turbine analysis method, both entirely coded in the Java language. The combined package provides analytical, graphical and data management tools which allow the user to

construct and control engine simulations by manipulating graphical objects on the computer display screen. Distributed simulations, including parallel processing and distributed database access across the Internet and World-Wide Web (WWW), are made possible through services provided by the Java environment.
Author
Gas Turbines; Graphical User Interface; Internets; Java (Programming Language); Propulsion; Propulsion System Performance; Simulation; World Wide Web; Aerothermodynamics; Propulsion System Configurations

19990028507 General Electric Co., Aircraft Engines, Cincinnati, OH USA
Parallel 3D Multi-Stage Simulation of a Turbofan Engine
Turner, Mark G., General Electric Co., USA; Topp, David A., General Electric Co., USA; 1998; 10p; In English; High Performance Computing and Communication (HPCC)/Computational AeroSsience (CAS) Workshop, USA; Sponsored by NASA Lewis Research Center, USA
Contract(s)/Grant(s): RTOP 509-10-11; Copyright; Avail: Issuing Activity, Hardcopy, Microfiche

A 3D multistage simulation of each component of a modern GE Turbofan engine has been made. An axisymmetric view of this engine is presented in the document. This includes a fan, booster rig, high pressure compressor rig, high pressure turbine rig and a low pressure turbine rig. In the near future, all components will be run in a single calculation for a solution of 49 blade rows. The simulation exploits the use of parallel computations by using two levels of parallelism. Each blade row is run in parallel and each blade row grid is decomposed into several domains and run in parallel. 20 processors are used for the 4 blade row analysis. The average passage approach developed by John Adamczyk at NASA Lewis Research Center has been further developed and parallelized. This is APNASA Version A. It is a Navier-Stokes solver using a 4-stage explicit Runge-Kutta time marching scheme with variable time steps and residual smoothing for convergence acceleration. It has an implicit K-E turbulence model which uses an ADI solver to factor the matrix. Between 50 and 100 explicit time steps are solved before a blade row body force is calculated and exchanged with the other blade rows. This outer iteration has been coined a "flip." Efforts have been made to make the solver linearly scaleable with the number of blade rows. Enough flips are run (between 50 and 200) so the solution in the entire machine is not changing. The K-E equations are generally solved every other explicit time step. One of the key requirements in the development of the parallel code was to make the parallel solution exactly (bit for bit) match the serial solution. This has helped isolate many small parallel bugs and guarantee the parallelization was done correctly. The domain decomposition is done only in the axial direction since the number of points axially is much larger than the other two directions. This code uses MPI for message passing. The parallel speed up of the solver portion (no 1/0 or body force calculation) for a grid which has 227 points axially.
Derived from text
Convergence; Navier-Stokes Equation; Runge-Kutta Method; Simulation; Turbofan Engines; Parallel Processing (Computers); Computational Fluid Dynamics; K-Epsilon Turbulence Model

19990028565 NASA Lewis Research Center, Cleveland, OH USA
Fuel injector patternation evaluation in advanced liquid-fueled, high pressure, gas turbine combustors, using nonintrusive optical diagnostic techniques
Locke, R. J., NYMA, Inc., USA; Hicks, Y. R., NASA Lewis Research Center, USA; Anderson, R. C., NASA Lewis Research Center, USA; Zaller, M. M., NASA Lewis Research Center, USA; JANNAF Airbreathing Propulsion Subcommittee Meeting; October 1997; Volume 1, pp. 61-71; In English; See also 19990028559; No Copyright; Avail: CPIA, 10630 Little Patuxent Pkwy., Suite 202, Columbia, MD 21044-3200 HC, Hardcopy, Microfiche

Planar laser-induced fluorescence (PLIF) imaging and planar Mie scattering are used to examine the fuel distribution pattern (patternation) for advanced fuel injector concepts in kerosene burning, high pressure gas turbine combustors. Three diverse fuel injector concepts for aerospace applications were investigated under a broad range of operating conditions. Fuel PLIF patternation results are contrasted with those obtained by planar Mie scattering. Further comparison is also made for one injector with data obtained through phase Doppler measurements. Differences in spray patterns for diverse conditions and fuel injector configurations are readily discernible. An examination of the data has shown that a direct determination of the fuel spray angle at realistic conditions is also possible. The results obtained in this study demonstrate the applicability and usefulness of these nonintrusive optical techniques for investigating fuel spray patternation under actual combustor conditions.
Author
Combustion Chambers; Fuel Injection; Imaging Techniques; Injectors; Kerosene; Laser Induced Fluorescence; Mie Scattering; Gas Turbine Engines; Distribution (Property)

19990028568 Pratt and Whitney Aircraft, West Palm Beach, FL USA

Applications of endothermic research technology to the high speed civil transport

Glickstein, M. R., Pratt and Whitney Aircraft, USA; Spadaccini, L. J., United Technologies Research Center, USA; JANNAF Airbreathing Propulsion Subcommittee Meeting; October 1997; Volume 1, pp. 99-106; In English; See also 19990028559

Contract(s)/Grant(s): NAS3-27397; No Copyright; Avail: CPIA, 10630 Little Patuxent Pkwy., Suite 202, Columbia, MD 21044-3200 HC, Hardcopy, Microfiche

The success of strategies for controlling emissions and enhancing performance in High Speed Research applications may be increased by more effective utilization of the heat sink afforded by the fuel in the vehicle thermal management system. This study quantifies the potential benefits associated with the use of supercritical preheating and endothermic cracking of jet fuel prior to combustion to enhance the thermal management capabilities of the propulsion systems in the High Speed Civil Transport (HSCT). A fuel-cooled thermal management system, consisting of plate-fin heat exchangers and a small auxiliary compressor, is defined for the HSCT, integrated with the engine, and an assessment of the effect on engine performance, weight, and operating cost is performed. The analysis indicates significant savings due a projected improvement in fuel economy, and the potential for additional benefit if the cycle is modified to take full advantage of all the heat sink available in the fuel.

Author

Endothermic Fuels; Endothermic Reactions; Fuel Combustion; Fuel Systems; Heat Sinks; Jet Engine Fuels; Propulsion System Configurations; Heat Exchangers; Supersonic Commercial Air Transport; Turbine Engines; Cooling Systems

19990028821 Stress Technology, Inc., Rochester, NY USA

Engine Health Monitoring System for Advanced Diagnostic Monitoring for Gas Turbine Engines *Final Report, 13 Nov. 1995 - 20 Feb. 1998*

Roemer, Michael J.; Feb. 1998; 91p; In English

Contract(s)/Grant(s): F33615-95-C-2567; AF Proj. 3005

Report No.(s): AD-A359658; AFRL-PR-WP-TR-1998-2120; No Copyright; Avail: CASI; A05, Hardcopy; A01, Microfiche

A prototype USAF engine health management (EHM) system was developed and ground tested during this Phase II SBIR program. The EHM system is capable of real-time mechanical monitoring and diagnostics, aero-thermal performance monitoring and diagnostics, and "engine signature" based life accumulation. For the first time, state-of-the-art anomaly detection, monitoring, diagnosis and advanced life prediction analysis were integrated together in a single real-time engine health monitoring system. Additionally, the EHM system was developed to assist the 2-level maintenance concept and IHPTET initiatives.

DTIC

Engine Monitoring Instruments; Systems Health Monitoring; Gas Turbine Engines; Real Time Operation

19990032063 Department of Energy, Assistant Secretary for Energy Efficiency and Renewable Energy, Washington, DC USA

Verification of Creep Performance of a Ceramic Gas Turbine Blade

Lin, H. T., Department of Energy, USA; Becher, P. F., Department of Energy, USA; Ferber, M. K., Department of Energy, USA; Parthasarathy, V., Department of Energy, USA; Mar. 31, 1998; 6p; In English; 2nd; Science of Engineering Ceramics, USA

Report No.(s): DE98-005762; ORNL/CP-97457; CONF-980912; No Copyright; Avail: Department of Energy Information Bridge, Microfiche

Tensile creep tests were carried out on a Norton NT164 silicon nitride ceramic turbine blade containing 4 wt.% Y2O3 sintering additive at 1,370 C in air under selected stress levels. The objective of this study was to measure the creep properties of test specimens extracted from a complex shaped ceramic gas turbine blade to verify the response of actual components. The creep results indicated that specimens from both the airfoil and dovetail sections exhibited creep rates that were about 4 to 100 times higher than those obtained from both the buttonhead and dogbone creep specimens machined from the developmental billets fabricated with the same composition and processing procedures. Electron microscopy analyses suggested that high creep rates and short lifetimes observed in specimens extracted from the turbine blade resulted from a higher glassy phase(s) content and smaller number density of elongated grain microstructure. Silicon nitride ceramics with an in situ reinforced elongated microstructure have been the primary candidates for both advanced automotive and land-based gas turbine engine applications.

NTIS

Tensile Creep; Creep Tests; Turbine Blades; Silicon Nitrides; Ceramics

09
RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tubes; and aircraft engine test stands.

19990028346 NASA Goddard Space Flight Center, Greenbelt, MD USA
Refurbishment and Automation of Thermal Vacuum Facilities at NASA/GSFC
Dunn, Jamie, NASA Goddard Space Flight Center, USA; Gomez, Carlos, NASA Goddard Space Flight Center, USA; Donohue, John, NASA Goddard Space Flight Center, USA; Johnson, Chris, ManTech Systems Engineering Corp., USA; Palmer, John, ManTech Systems Engineering Corp., USA; Sushon, Janet, ManTech Systems Engineering Corp., USA; 1998; In English; 20th; Space Simulation, 27-29 Oct. 1998, USA
Report No.(s): NASA/CR-1998-208598; NAS 1.26:208598; Copyright; Avail: Issuing Activity, Hardcopy, Microfiche

The thermal vacuum facilities located at the Goddard Space Flight Center (GSFC) have supported both manned and unmanned space flight since the 1960s. Of the eleven facilities, currently ten of the systems are scheduled for refurbishment or replacement as part of a five-year implementation. Expected return on investment includes the reduction in test schedules, improvements in safety of facility operations, and reduction in the personnel support required for a test. Additionally, GSFC will become a global resource renowned for expertise in thermal engineering, mechanical engineering, and for the automation of thermal vacuum facilities and tests. Automation of the thermal vacuum facilities includes the utilization of Programmable Logic Controllers (PLCs), the use of Supervisory Control and Data Acquisition (SCADA) systems, and the development of a centralized Test Data Management System. These components allow the computer control and automation of mechanical components such as valves and pumps. The project of refurbishment and automation began in 1996 and has resulted in complete computer control of one facility (Facility 281), and the integration of electronically controlled devices and PLCs in multiple others.
Author
Thermal Vacuum Tests; Systems Engineering; Data Management; Management Systems; Data Acquisition

19990028431 Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen, Germany
Operational experience and test results in the adaptive test section of the DLR transonic tunnel
Holst, H., Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Germany; Bock, K-W., Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Germany; Lorenz-Meyer, W., Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Germany; Oberdieck, F., Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Germany; Hermes, M., Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Germany; The Aeronautical Journal; November 1997; Volume 101, No. 1009, pp. 421-428; In English; Windtunnel and Windtunnel Testing Techniques CEAS Forum, Apr. 1997, Cambridge, UK; See also 19990028427
Report No.(s): Paper-2281; Copyright; Avail: Issuing Activity (The Royal Aeronautical Society, 4 Hamilton Place, London WIV 0BQ), Hardcopy, Microfiche

The transonic facility of DLR Goettingen (TWG) has been modernized with respect to an improved flow quality and flow simulation, as well as to the logistics of exchangeable test sections, operational reliability and productivity. It is presently equipped with a Laval nozzle for supersonic flow measurements, a perforated test section (6% open, 60 deg. slanted holes) for transonic measurements, and a two-dimensional adaptive test section for subsonic measurements. The latter can perform two-dimensional adaptive tests on wing profiles, using the Cauchy integral formula for wall adaptation, as well as two-dimensional wall adaptation for three-dimensional models, utilising the Wedemeyer/Lamarche procedure, also known as the VKI method. For both cases, it is shown that the wall adaptation was successful. The 3D force results compare quite well to test results from the perforated test section, as well as to nominally interference-free results. The pressure distribution from the wing profile tests compare quite well to theoretical calculations. In the course of windtunnel modernization, the transonic facility of DLR Goettingen has been equipped with the new software system DeAs for data acquisition and control of experimental facilities. In this environment the wall adaptation programs had to be implemented. Before adjusting the computed wall shape, it has to be controlled in the loop for sufficient accuracy and tolerable bending stresses. A simplified finite element method - also taking into account the pressure loads at the wall - is used for this purpose. The simplified approach has been checked against more detailed computations using ANSYS and NASTRAN.
Author
Finite Element Method; Pressure Distribution; Supersonic Flow; Transonic Wind Tunnels; Wind Tunnel Walls; Slotted Wind Tunnels; Wind Tunnel Calibration; Cauchy Integral Formula

19990028432 Office National d'Etudes et de Recherches Aerospatiales, Modane, France
On the use of large scale windtunnel models
Giacchetto, A., Office National d'Etudes et de Recherches Aerospatiales, France; The Aeronautical Journal; November 1997; Volume 101, No. 1009, pp. 429-437; In English; Windtunnel Testing Technique CEAS Forum, Apr. 1997, Cambridge, UK; See also 19990028427
Report No.(s): Paper-2284; Copyright; Avail: Issuing Activity (The Royal Aeronautical Society, 4 Hamilton Place, London WIV 0BQ), Hardcopy, Microfiche

The use of large scale windtunnel models offers considerable advantages to an experimenter: (1) the possibility of obtaining high Reynolds number, certainly significant and sometimes equal to that in flight, for moderate stagnation pressures; (2) an accurate representation of geometric elements, i.e. good form similitude (it is necessary to emphasise the importance of being very thorough in this area); (3) large internal volume, which enable numerous transducers to be implanted, ambitious experimental devices and means of remote control of model motorization; and (4) test conditions remain those corresponding to industrial manufacturing methods and so avoid problems related to extreme miniaturization. Additionally, there exist some test conditions for which scale reduction is limited or even impossible; for example, because of physical phenomena, limitation in industrial methods of miniaturisation, or quite simply because the subject is itself the flying object. These conditions are applicable to all tests whether industrial or research. They are especially true for industrial tests where these concern important decisions. They are also true for research tests whenever they need to be sufficiently close to flight reality. Wind-tunnels are always a means to reduce the costs and risks of aeronautical project developments. The risk taken in extrapolating from windtunnel tests to flight are lower when the test is more realistic and this gives a clear advantage to tests on large sized models.
Author
High Reynolds Number; Scale Models; Wind Tunnel Models; Wind Tunnels; External Store Separation; Wind Tunnel Tests

10
ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; space communications, spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

19990028634 Office of Science and Technology, Washington, DC USA
Interagency Report on Orbital Debris
November 1995; 90p; In English; Original contains color illustrations
Report No.(s): LC-95-72164; No Copyright; Avail: CASI; A05, Hardcopy; A01, Microfiche

Taking into consideration the results of the National Research Council orbital debris technical assessment study funded by the National Aeronautics and Space Administration, an Interagency Working Group under the direction of the Office of Science and Technology Policy and the National Security Council revised and updated the 1989 Report on Orbital Debris. This 1995 Report contains an up-to-date portrait of our measurement, modeling, and mitigation efforts and a set of recommendations outlining specific steps we should pursue, both domestically and internationally, to minimize the potential hazards posed by orbital debris.
Author
Space Debris; Flight Hazards; Space Flight; Low Earth Orbits; Earth Orbital Environments; Geosynchronous Orbits

19990028487 NASA Lewis Research Center, Cleveland, OH USA
Rocket-Based Combined Cycle Propulsion System Testing
Perkins, H. Douglas, NASA Lewis Research Center, USA; Thomas, Scott R., NASA Lewis Research Center, USA; DeBonis, James R., NASA Lewis Research Center, USA; Journal of Propulsion and Power; November 1998; Volume 14, No. 6, pp. 1065-1076; In English; 35th; Aerospace Sciences, 6-9 Jan. 1997, Reno, NV, USA; Sponsored by American Inst. of Aeronautics and Astronautics, USA
Report No.(s): AIAA Paper 97-0565; Copyright; Avail: Issuing Activity, Hardcopy, Microfiche

ROCKET-based combined cycle (RBCC) engines combine the high thrust-to-weight ratio of rockets with the high specific impulse of ramjets in a single integrated propulsion system that is capable of generating thrust from sea-level-static to high Mach number conditions. The strutjet tested at the NASA Lewis Research Center's (LeRC) Hypersonic Tunnel Facility (HTF) is one example of this engine concept that is being developed cooperatively by a government and industry team. The strutjet is an ejector-ramjet engine in which small, fuel-rich mono-methyl-hydrazine (MMH)/inhibited red fuming nitric acid (IRFNA) rocket cham-

bers are embedded into the trailing edges of the inlet compression struts. The engine operates as an ejector ramjet from takeoff to about Mach 3. At low Mach numbers, entrained air is completely consumed by the fuel-rich rocket exhaust. As freestream Mach number and air-flow increase, JP-10 fuel is introduced to maintain the stoichiometric combustion of all available oxygen. At approximately Mach 3, the strut rockets are turned off. Above Mach 3, the engine operates as a thermally choked ramjet, and then transitions to supersonic combustion (scramjet) mode. For space-launch applications, the rockets are reignited at a Mach number beyond which air-breathing propulsion becomes impractical. The purpose of this paper is to present the increased operating range achieved by the HTF and the high fidelity of previously completed subscale tests and computational fluid dynamics (CFD) simulations of this engine configuration as demonstrated by the HTF engine data.
Derived from text
Propulsion System Performance; Rocket Engines; Thrust-Weight Ratio; High Impulse; Specific Impulse; Ramjet Engines; Hypersonic Wind Tunnels

19990028561 Alabama Univ., Huntsville, AL USA
Experimental investigation of a rocket based combined cycle (RBCC) engine in a direct-connect test facility
Nelson, K. W., Alabama Univ., USA; Hawk, C. W., Alabama Univ., USA; JANNAF Airbreathing Propulsion Subcommittee Meeting; October 1997; Volume 1, pp. 11-23; In English; See also 19990028559
Contract(s)/Grant(s): NGT8-52825; No Copyright; Avail: CPIA, 10630 Little Patuxent Pkwy., Suite 202, Columbia, MD 21044-3200 HC, Hardcopy, Microfiche

With the maturation of key technologies and the need for a more economical space transportation system, there is renewed interest in the Rocket Based Combined Cycle (RBCC) engine. A RBCC is an integration of rocket and airbreathing propulsion into a single system. The RBCC potentially combines the advantages of a rocket's thrust to weight ratio with an airbreather's superior specific impulse. An experimental study to investigate RBCC operation at ramjet and scramjet flight conditions is currently underway. The hardware is being tested in the Direct Connect Supersonic Combustion Test Facility at NASA Langley Research Center. The facility's hydrogen/oxygen/air vitiated heater is capable of simulating flight total enthalpies up to Mach 7.5. The apparatus being tested consists of a gaseous hydrogen/oxygen linear, strut rocket ejector, provided by Aerojet Propulsion Company, and a dual-mode scramjet combustor section. A unique, direct thrust measurement system was also developed for this experiment. Typical freestream Mach number simulations will range from 4 to 6.5 based on total temperature. The effectiveness of the rocket as a fuel injector, pilot, and/or flameholder will be addressed as well as its impact on combined operation performance, namely thrust and Specific Impulse (I(sub sp)). The purpose of this paper is to provide a description of the experiment and present preliminary test results. The preliminary results of an analytical study of the configuration using a one-dimensional thermo-equilibrium code are also presented.
Author
Air Breathing Engines; Ramjet Engines; Space Transportation System; Thrust; Rocket Engines; Reusable Rocket Engines; Spacecraft Propulsion; Turborocket Engines; Experiment Design; Rocket Engine Design

19990028562 Pennsylvania State Univ., Dept. of Mechanical Engineering, University Park, PA USA
Rocket ejector studies for application to RBCC engines: An integrated experimental/CFD approach
Lehman, S. P. M., Pennsylvania State Univ., USA; Broda, J. C., Pennsylvania State Univ., USA; Santoro, R. J., Pennsylvania State Univ., USA; Merkle, C. L., Pennsylvania State Univ., USA; JANNAF Airbreathing Propulsion Subcommittee Meeting; October 1997; Volume 1, pp. 25-34; In English; See also 19990028559
Contract(s)/Grant(s): NAS8-40890; No Copyright; Avail: CPIA, 10630 Little Patuxent Pkwy., Suite 202, Columbia, MD 21044-3200 HC, Hardcopy, Microfiche

The rocket based combined cycle (RBCC) approach is a promising concept for advanced space transportation systems. The RBCC engine concept integrates air breathing propulsion with rocket propulsion to exploit atmospheric air as the oxidizer during the course of the vehicle trajectory. Although there are quite a few design variations, the gamut of concepts includes four flight regimes, viz. rocket-ejector, ramjet, scramjet and all rocket. of these four flight regimes, the rocket-ejector mode that encompasses the zero to roughly two Mach number range of the flight vehicle, is the least well understood. The goal of the current project is to investigate this mode utilizing a joint experimental/analytical approach. The experimental phase of the program includes studying the mixing and combustion characteristics of the rocket-ejector system utilizing state-of-the-art diagnostic techniques. In this vein, a two-dimensional variable geometry rocket-ejector system with enhanced optical access has been designed and fabricated.

The system design is based on an earlier study, however, the goal of this program is to systematically increase the range of understanding over a wide range of flow/geometry parameters. Concurrently with the experimental phase, a computational fluid dynamic analytical approach is also being developed and utilized to investigate the rocket-ejector mode of the RBCC engine. In this paper, the rocket-ejector experiments/analyses are described along with initial results.
Author
Air Breathing Engines; Computational Fluid Dynamics; Ramjet Engines; Space Transportation System; Propulsion; Rocket Engines; Experiment Design; Rocket Engine Design; Ejectors

11
CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.

19990028401 Department of Energy, Office of Financial Management and Controller, Washington, DC USA
Deep high-aspect ratio Si etching for advanced packaging technologies
Shul, R. J., Department of Energy, USA; Willison, C. G., Department of Energy, USA; Sullivan, C. T., Department of Energy, USA; Kravitz, S. H., Department of Energy, USA; Zhang, L., Department of Energy, USA; May 31, 1998; 12p; In English; 193rd, USA; Sponsored by Electrochemical Society, Inc., USA
Report No.(s): DE98-003344; SAND-98-0608C; No Copyright; Avail: Department of Energy Information Bridge, Microfiche

Deep high-aspect ratio Si etching (HARSE) has shown potential application for passive self-alignment of dissimilar materials and devices on Si carriers or waferboards. The Si can be etched to specific depths and; lateral dimensions to accurately place or locate discrete components (i.e lasers, photodetectors, and fiber optics) on a Si carrier. It is critical to develop processes which maintain the dimensions of the mask, yield highly anisotropic profiles for deep features, and maintain the anisotropy at the base of the etched feature. In this paper the authors report process conditions for HARSE which yield etch rates exceeding 3 (micro)m/min and well controlled, highly anisotropic etch profiles. Examples for potential application to advanced packaging technologies will also be shown.
NTIS
High Aspect Ratio; Etching; Silicon; Packaging

19990032212 NASA Langley Research Center, Hampton, VA USA
Development of Textile Reinforced Composites for Aircraft Structures
Dexter, H. Benson, NASA Langley Research Center, USA; 1998; 10p; In English; 4th; Textile Composites, 12-14 Oct. 1998, Kyoto, Japan; No Copyright; Avail: CASI; A02, Hardcopy; A01, Microfiche

NASA has been a leader in development of composite materials for aircraft applications during the past 25 years. In the early 1980's NASA and others conducted research to improve damage tolerance of composite structures through the use of toughened resins but these resins were not cost-effective. The aircraft industry wanted affordable, robust structures that could withstand the rigors of flight service with minimal damage. The cost and damage tolerance barriers of conventional laminated composites led NASA to focus on new concepts in composites which would incorporate the automated manufacturing methods of the textiles industry and which would incorporate through-the-thickness reinforcements. The NASA Advanced Composites Technology (ACT) Program provided the resources to extensively investigate the application of textile processes to next generation aircraft wing and fuselage structures. This paper discusses advanced textile material forms that have been developed, innovative machine concepts and key technology advancements required for future application of textile reinforced composites in commercial transport aircraft. Multiaxial warp knitting, triaxial braiding and through-the-thickness stitching are the three textile processes that have surfaced as the most promising for further development. Textile reinforced composite structural elements that have been developed in the NASA ACT Program are discussed. Included are braided fuselage frames and window-belt reinforcements, woven/stitched lower fuselage side panels, stitched multiaxial warp knit wing skins, and braided wing stiffeners. In addition, low-cost processing concepts such as resin transfer molding (RTM), resin film infusion (RFI), and vacuum-assisted resin transfer molding (VARTM) are discussed. Process modeling concepts to predict resin flow and cure in textile preforms are also discussed.
Author
Composite Materials; Aircraft Structures; Cost Effectiveness; Textiles; Resins; Composite Structures; Laminates

19990028764 NASA Langley Research Center, Hampton, VA USA

Determination of the Corrosive Conditions Present within Aircraft Lap-Splice Joints

Lewis, Karen S., Virginia Univ., USA; Kelly, Robert G., Virginia Univ., USA; Piascik, Robert S., NASA Langley Research Center, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 841-852; In English; See also 19990028721; No Copyright; Avail: CASI; A03, Hardcopy; A06, Microfiche

The complexity of airframe structure lends itself to damage resulting from crevice corrosion. Fuselage lap-splice joints are a particularly important structural detail in this regard because of the difficulty associated with detection and measurement of corrosion in these occluded regions. The objective of this work is to develop a laboratory corrosion test protocol to identify the chemistry to which lap joints are exposed and to develop a model of the corrosion within the joints. A protocol for collecting and identifying the chemistry of airframe crevice corrosion has been developed. Capillary electrophoresis (CE) is used to identify the ionic species contained in corrosion product samples removed from fuselage lap splice joints. CE analysis has been performed on over sixty corrosion product samples removed from both civilian and military aircraft. Over twenty different ions have been detected. Measurements of pH of wetted corroded surfaces indicated an alkaline occluded solution. After determining the species present and their relative concentrations, the resultant solution was reproduced in bulk and electrochemical tests were performed to determine the corrosion rate. Electrochemical analyses of the behavior of AA2024-T3 in these solutions gave corrosion rates of up to 250 microns per year (10 mpy). Additional tests have determined the relative importance of each of the detected ions in model solutions used for future predictive tests. The statistically significant ions have been used to create a second generation solution. Laboratory studies have also included exposure tests involving artificial lap joints exposed to various simulated bulk and crevice environments. The extent and morphology of the attack in artificial lap joints has been compared to studies of corroded samples from actual aircraft. Other effects, such as temperature and potential, as well as the impact of the environment on fatigue crack growth have also been studied.

Author

Lap Joints; Fuselages; Corrosion Tests; Cavitation Corrosion; Electrophoresis; Structural Analysis

19990028767 Honeywell Technology Center, Minneapolis, MN USA

Acoustic Detection of In Situ Corrosion in Aging Aircraft

Schoess, Jeffrey N., Honeywell Technology Center, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 872-874; In English; See also 19990028721; No Copyright; Avail: CASI; A01, Hardcopy; A06, Microfiche

Hidden and inaccessible corrosion in aircraft structures is the number-one logistics problem for the U.S. Air Force, with an estimated maintenance cost in excess of $1.0 billion per year in 1990-equivalent dollars. Reliable detection of hidden corrosion damage using conventional nondestructive inspection (NDI) techniques is a difficult task, requiring significant maintenance training and manpower to access damaged structural locations. This paper summarizes a novel in situ measurement approach using stress-wave acoustic emission (AE) technology to detect and quantify corrosion damage without removing structural panels. A summary problem statement, existing NDI methods, and their limitations, corrosion factors, design concept approach for using AE, and design implementation details are presented.

Author

Structural Analysis; Aircraft Structures; In Situ Measurement; Acoustic Emission; Corrosion; Fault Detection; Nondestructive Tests

19990028564 Boeing North American, Inc., Canoga Park, CA USA

Endothermic fuels: A historical perspective

Lander, H. R., Boeing North American, Inc., USA; JANNAF Airbreathing Propulsion Subcommittee Meeting; October 1997; Volume 1, pp. 45-60; In English; See also 19990028559; No Copyright; Avail: CPIA, 10630 Little Patuxent Pkwy., Suite 202, Columbia, MD 21044-3200 HC, Hardcopy, Microfiche

The term endothermic fuels no longer conjures fear in the aircraft or engine designer. It is no longer viewed as a figment of the imagination of the processing industry. The need for a hydrocarbon fuel for long range hypersonic missions, is attractive because of the volumetric heating value of these petroleum-derived fuels. However, the main characteristic which makes these fuels attractive is their ability to react at certain conditions to absorb heat, thereby cooling the hot structures of the vehicle and also producing highly reactive products. Endothermic fuels evolved from gas turbine fuels (jet fuels) which were developed after World War II. This early research had led to JP-7, used in the SR71, which was the first operational jet fuel specifically defined for high speed flights (about Mach 3), where cooling temperatures were thought to exceed the limit of liquid hydrocarbon fuels. JP-7 development opened a technology of using fuels to cool into the supercritical regime (>700 F). The operational record of the Mach 3+ SR71 reinforced the need for evaluating the use of liquid jet fuels at even higher speeds. Research, in this area, uncov-

ered conditions where the base fuel would react through the absorption of heat (the endothermic reaction). This paper reviews the evolution of aviation fuels, starting with the first turbojets leading to present and a glimpse at the future. Like any evolutionary process, progress proceeds, sometimes slowly, and leads to a better understanding and eventually a completely different system. Aviation fuel technology has evolved with input from the entire industry, the refiners, engine and aircraft manufacturers and the government.
Author
Endothermic Fuels; Endothermic Reactions; Gas Turbines; Hydrocarbon Fuels; Hypersonics; Jet Engine Fuels; Turbojet Engines; Histories

12
ENGINEERING

Includes engineering (general); communications and radar; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

19990028559 Johns Hopkins Univ., Chemical Propulsion Information Agency, Columbia, MD USA
JANNAF Airbreathing Propulsion Subcommittee Meeting, Volume 1, *12 Dec. 1996 - 27 Oct. 1997*
Fry, Ronald S., Editor, Johns Hopkins Univ., USA; Gannaway, Mary T., Editor, Johns Hopkins Univ., USA; JANNAF Airbreathing Propulsion Subcommittee Meeting; October 1997; 117p; In English, 27-30 Oct. 1997, West Palm Beach, FL, USA; See also 19990028560 through 19990028568
Contract(s)/Grant(s): SPO700-97-D-4004
Report No.(s): CPIA-Publ-666-Vol-1; No Copyright; Avail: CPIA, 10630 Little Patuxent Pkwy., Suite 202, Columbia, MD 21044-3200 HC, Hardcopy, Microfiche

This publication, Volume I of four volumes, contains nine unclassified/unlimited distribution papers presented at the 1997 meeting of the JANNAF Airbreathing Propulsion Subcommittee (APS). The JANNAF papers in this volume review advanced and combined cycle technology; hypersonic fuels; ramjet, scramjet and gas turbine design methodologies; and, thermal management for advanced systems.
Author
Engine Design; Gas Turbine Engines; Conferences; Air Breathing Engines; Fuel Combustion; Propulsion System Performance; Propulsion System Configurations

19990028505 NASA Goddard Space Flight Center, Greenbelt, MD USA
Design and Testing of a Cryogenic Capillary Pumped Loop Flight Experiment
Bugby, David C., Swales Aerospace, USA; Kroliczek, Edward J., Swales Aerospace, USA; Ku, Jentung, NASA Goddard Space Flight Center, USA; Swanson, Ted, NASA Goddard Space Flight Center, USA; Tomlinson, B. J., Air Force Research Lab., USA; Davis, Thomas M., Air Force Research Lab., USA; Baumann, Jane, Cullimore and Ring Technologies, Inc., USA; Cullimore, Brent, Cullimore and Ring Technologies, Inc., USA; 1998; 10p; In English; No Copyright; Avail: CASI; A02, Hardcopy; A01, Microfiche

This paper details the flight configuration and pre-flight performance test results of the fifth generation cryogenic capillary pumped loop (CCPL-5). This device will fly on STS-95 in October 1998 as part of the CRYOTSU Flight Experiment. This flight represents the first in-space demonstration of a CCPL; a miniaturized two-phase fluid circulator for thermally linking cryogenic components. CCPL-5 utilizes N2 as the working fluid and has a practical operating range of 75-110 K. Test results indicate that CCPL-5, which weighs about 200 grams, can transport over 10 W of cooling a distance of 0.25 m (or more) with less than a 5 K temperature drop.
Author
Cryogenic Cooling; Flight Characteristics; Performance Tests; Cryogenics

19990028506 NASA Lewis Research Center, Cleveland, OH USA
Flight Tests on a Fiber Optic Temperature Sensor
Tuma, Margaret L., NASA Lewis Research Center, USA; Sawatari, Takeo, Sentec Corp., USA; Lin, Yuping, Sentec Corp., USA; Elam, Kristie A., Gilcrest Electric, USA; 1998; 7p; In English; 17th; Digital Avionics Systems Conference (DASC), 31 Oct. - 6 Nov. 1998, Bellevue, WA, USA; Sponsored by Institute of Electrical and Electronics Engineers, USA
Contract(s)/Grant(s): RTOP 519-30-53; Copyright; Avail: Issuing Activity, Hardcopy, Microfiche

For aircraft engine control, one key parameter to detect on an airplane is the exhaust gas temperature (EGT). Presently, thermocouples are used to perform this measurement. These electrical sensors perform adequately; however, fully utilizing the benefits of optical sensors requires replacing electrical architectures with optical architectures. Part of this requires replacing electrical sensors with optical sensors, such as the EGT sensor chosen for these tests. The objective of the development and testing of this prototype sensor system was to determine the feasibility of operating an optical sensor in a hostile aircraft environment. The fiber optic sensor system was developed to measure temperatures from 20C to 600C in an aircraft environment and was utilized to monitor the EGT of an OV-10D aircraft engine. The sensor has successfully flown over 50 hours and proven to be immune to surface deterioration of the optical element (located inside the sensor head) and able to withstand and operate in normal and sustained severe flight conditions where forces on the airplane exceeded 4 g's. Potential commercial uses for this sensor include monitoring temperature for aeropropulsion system control, military vehicle and naval engine control, conventional and nuclear power plant monitoring and industrial plan monitoring where EMI issues are critical.
Author
Aircraft Engines; Exhaust Gases; Fiber Optics; Gas Temperature; Optical Measuring Instruments; Temperature Sensors; Fabry-Perot Interferometers

19990032240 Illinois Univ., Aviation Research Lab., Savoy, IL USA
Allocation of Attention with Head-Up Displays ***Final Report***
Wickens, C. D.; Ververs, P. M.; Nov. 1998; 19p; In English
Report No.(s): AD-A359344; DOT/FAA/AM-98/28; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

Two experiments examined the effects of display location (head up vs. head down) and image intensity/clutter on flight path performance and mid-air target detection in a general aviation cruise flight environment. In Experiment 1, a low-fidelity simulation, both near-domain and far-domain Instrumentation were presented at the same optical distance. Detection of commanded flight changes and maintenance of desired flight path flight were generally better in the head-down condition, an advantage attributed to the superior image contrast ratios in that condition. In contrast, target detection was superior with the head-up display, reflecting an attentional tradeoff Experiment 2 was performed with pilots viewing far-domain imagery (and airborne targets) on an Evans and Sutherland display positioned near optical infinity, head-up display (HUD) imagery at the same optical distance, and head-down imagery at a near distance typical of the instrument panel. The degree of clutter was also varied and image contrast ratios were equated between head-up and head-down viewing conditions. Flight performance was equivalent between the HUD and head-down locations. However, detection of both near-domain events (commanded changes) and far-domain targets was better in the HUD condition, revealing the HUD benefit of reduced scanning. Adding extra information (clutter) to the HUD inhibited detection of both events in both head-up and head-down locations. However, this clutter cost was diminished for far-domain target detection if the added information was "low-lighted." Flight performance was superior in clear weather, when the true horizon was available for viewing. The data provided little evidence that attention was modulated in depth (near vs. far domains), but rather suggested that attention was modulated between tasks (flight control and detection).
DTIC
Head-Up Displays; Flight Characteristics; Flight Control

19990032026 Department of Energy, Assistant Secretary for Fossil Energy, Washington, DC USA
Advanced gas turbine systems research ***Quarterly Report, 1 Oct. - 31 Dec. 1997***
Dec. 31, 1997; 50p; In English
Report No.(s): DE98-058977; DOE/MC/29061-12; No Copyright; Avail: Department of Energy Information Bridge, Microfiche

Major accomplishments by Advanced Gas Turbine Systems Research (AGTSR) during this reporting period are highlighted and then amplified in later sections of this report. Main areas of research are combustion, heat transfer, and materials. Gas turbines are used for power generation by utilities and industry and for propulsion.
NTIS
Gas Turbines; Gas Turbine Engines; Combustion; Heat Transfer

19990032028 Department of Energy, Assistant Secretary for Fossil Energy, Washington, DC USA
Advanced gas turbine systems research ***Quarterly Report, 1 Jul. - 30 Sep. 1997***
Dec. 31, 1997; 50p; In English
Report No.(s): DE98-058957; DOE/MC/29061-10; No Copyright; Avail: Department of Energy Information Bridge, Microfiche

Major accomplishments by Advanced Gas Turbine Systems Research (AGTSR) during this reporting period are highlighted and then amplified in later sections of this report. Main areas of research are combustion, heat transfer, and materials. Gas turbines are used for power generation by utilities and industry and for propulsion.
NTIS
Gas Turbines; Gas Turbine Engines; Combustion; Heat Transfer; Materials

19990028761 Sandia National Labs., FAA Airworthiness Assurance NDI Validation Center, Albuquerque, NM USA
Experimental Flight Test Vibration Measurements and Nondestructive Inspection on a USCG HC-130H Aircraft
Moore, David G., Sandia National Labs., USA; Jones, Craig R., Sandia National Labs., USA; Mihelic, Joseph E., Coast Guard, USA; Barnes, James D., Coast Guard, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 811-820; In English; See also 19990028721
Contract(s)/Grant(s): DE-ACO4-94-AL85000; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

This paper presents results of experimental flight test vibration measurements and structural inspections performed by the Federal Aviation Administration's Airworthiness Assurance NDI Validation Center (AANC) at Sandia National Laboratories and the U.S. Coast Guard Aircraft Repair and Supply Center (ARSC). Structural and aerodynamic changes induced by mounting a Forward Looking Infrared (FLIR) system on a USCG HC-130H aircraft are described. The FLIR adversely affected the air flow characteristics and structural vibration on the external skin of the aircraft's fight main wheel well fairing. Upon initial discovery of skin cracking and visual observation of skin vibration in flight by the FLIR, a baseline flight without the FLIR was conducted and compared to other measurements with the FLIR installed. Nondestructive inspection procedures were developed to detect cracks in the skin and supporting structural elements and document the initial structural condition of the aircraft. Inspection results and flight test vibration data revealed that the FLIR created higher than expected flight loading and was the possible source of the skin cracking. The Coast Guard performed significant structural repair and enhancement on this aircraft, and additional in-flight vibration measurements were collected on the strengthened area both with and without the FLIR installed. After three months of further operational FLIR usage, the new aircraft skin with the enhanced structural modification was reinspected and found to be free of flaws. Additional U.S. Coast Guard HC-130H aircraft are now being similarly modified to accommodate this FLIR system. Measurements of in-flight vibration levels with and without the FLIR installed, and both before and after the structural enhancement and repair were conducted on the skin and supporting structure in the aircraft's right main wheel fairing. Inspection results and techniques developed to verify the aircraft's structural integrity are also discussed.
Author
Vibration Measurement; Structural Vibration; Aircraft Structures; Structural Analysis; Skin (Structural Member); Cracking (Fracturing); Fairings

19990028798 Sandia National Labs., Airworthiness Assurance NDI Validation Center, Albuquerque, NM USA
Detection Reliability for Small Cracks Beneath Rivet Heads Using Eddy-Current Nondestructive Inspection Techniques
Final Report
Spencer, F. W., Sandia National Labs., USA; Dec. 1998; 62p; In English
Report No.(s): PB99--126864; No Copyright; Avail: CASI; A04, Hardcopy; A01, Microfiche

In order to assess the full potential of advanced eddy-current inspection technology on representative aircraft applications, the FAA's Airworthiness Assurance Nondestructive Inspection Validation Center (AANC) was tasked to assess the full capability of several advanced systems. The task involved inspections of several rivet skin splices--representative of actual aircraft structure--containing cracks ranging from 0.040-, 0.060-, and 0.080-inch standards, and thresholds were set to the lowest reasonable level for the particular system. The results demonstrated that some of the systems were able to reliably detect cracks as small as 0.040 inch with false call rates remained less than 1%.
NTIS
Crack Propagation; Aircraft Structures; Detection; Rivets; Reliability Analysis

19990028721 NASA Langley Research Center, Hampton, VA USA
The Second Joint NASA/FAA/DoD Conference on Aging Aircraft, Part 2
Harris, Charles E., Editor, NASA Langley Research Center, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999; 611p; In English; 2nd; Aging Aircraft, 31 Aug. - 3 Sep. 1998, Williamsburg, VA, USA; Sponsored by NASA Langley Research Center, USA; See also 19990028722 through 19990028771
Contract(s)/Grant(s): RTOP 538-10
Report No.(s): NASA/CP-1999-208982/PT2; L-17819B; NAS 1.55:208982/PT2; No Copyright; Avail: CASI; A99, Hardcopy; A06, Microfiche

The purpose of the Conference was to bring together world leaders in aviation safety research, aircraft design and manufacturing, fleet operation and aviation maintenance to disseminate information on current practices and advanced technologies that will assure the continued airworthiness of the aging aircraft in the military and commercial fleets. The Conference included reviews of current industry practices, assessments of future technology requirements, and status of aviation safety research. The Conference provided an opportunity for interactions among the key personnel in the research and technology development community, the original equipment manufacturers, commercial airline operators, military fleet operators, aviation maintenance, and aircraft certification and regulatory authorities. Conference participation was unrestricted and open to the international aviation community. Appendix B contains the name and addresses of the 623 participants in the Conference.
Author
Conferences; Aircraft Reliability; Structural Analysis; Fracture Mechanics; Cracking (Fracturing); Crack Propagation; Aircraft Structures; Aging (Materials); Structural Failure; Fault Detection; Fatigue (Materials)

19990028722 Technische Univ., Inst. of Aircraft Design and Lightweight Structures, Brunswick, Germany
On the Assessment of the Criticality of Crack Scenarios with Respect to Widespread Fatigue Damage
Horst, Peter, Technische Univ., Germany; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 387-396; In English; See also 19990028721; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

The main question in the assessment of Widespread Fatigue Damage (WFD) criticality is the question how critical certain crack and crack initiation scenarios are, with or without combination with the residual strength problem. This paper deals with methods for the assessment of the criticality of crack scenarios. Emphasis is put on the question of deteriorating effects.
Author
Aircraft Structures; Fatigue (Materials); Crack Initiation; Cracks; Deterioration; Damage

19990028723 NASA Langley Research Center, Hampton, VA USA
The Growth of Multi-Site Fatigue Damage in Fuselage Lap Joints
Piascik, Robert S., NASA Langley Research Center, USA; Willard, Scott A., Lockheed Engineering and Sciences Co., USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 397-407; In English; See also 19990028721; No Copyright; Avail: CASI; A03, Hardcopy; A06, Microfiche

Destructive examinations were performed to document the progression of multi-site damage (MSD) in three lap joint panels that were removed from a full scale fuselage test article that was tested to 60,000 full pressurization cycles. Similar fatigue crack growth characteristics were observed for small cracks (50 microns to 10 mm) emanating from counter bore rivets, straight shank rivets, and 100 deg counter sink rivets. Good correlation of the fatigue crack growth data base obtained in this study and FASTRAN Code predictions show that the growth of MSD in the fuselage lap joint structure can be predicted by fracture mechanics based methods.
Author
Fuselages; Lap Joints; Riveted Joints; Damage; Crack Propagation; Fatigue (Materials); Short Cracks; Crack Initiation; Damage Assessment

19990028724 NASA Langley Research Center, Hampton, VA USA
Residual Strength Pressure Tests and Nonlinear Analyses of Stringer- and Frame-Stiffened Aluminum Fuselage Panels with Longitudinal Cracks
Young, Richard D., NASA Langley Research Center, USA; Rouse, Marshall, NASA Langley Research Center, USA; Ambur, Damodar R., NASA Langley Research Center, USA; Starnes, James H., Jr., NASA Langley Research Center, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 408-426; In English; See also 19990028721; No Copyright; Avail: CASI; A03, Hardcopy; A06, Microfiche

The results of residual strength pressure tests and nonlinear analyses of stringer- and frame-stiffened aluminum fuselage panels with longitudinal cracks are presented. Two types of damage are considered: a longitudinal crack located midway between stringers, and a longitudinal crack adjacent to a stringer and along a row of fasteners in a lap joint that has multiple-site damage (MSD). In both cases, the longitudinal crack is centered on a severed frame. The panels are subjected to internal pressure plus axial tension loads. The axial tension loads are equivalent to a bulkhead pressure load. Nonlinear elastic-plastic residual strength analyses of the fuselage panels are conducted using a finite element program and the crack-tip-opening-angle (CTOA) fracture criterion. Predicted crack growth and residual strength results from nonlinear analyses of the stiffened fuselage panels are

compared with experimental measurements and observations. Both the test and analysis results indicate that the presence of MSD affects crack growth stability and reduces the residual strength of stiffened fuselage shells with long cracks.
Author
Fuselages; Load Tests; Structural Analysis; Crack Tips; Finite Element Method; Cracking (Fracturing); Surface Cracks; Crack Propagation

19990028725 Lockheed Martin Aeronautical Systems, Marietta, GA USA
Residual Strength Analysis of Skin Splices with Multiple Site Damage
Ingram, J. E., Lockheed Martin Aeronautical Systems, USA; Kwon, Y. S., Lockheed Martin Aeronautical Systems, USA; Duffie, K. J., Lockheed Martin Aeronautical Systems, USA; Irby, W. D., Lockheed Martin Aeronautical Systems, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 427-436; In English; See also 19990028721; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

The widespread fatigue damage (WFD) assessment of the L-1011 aircraft has necessitated a significant update to the damage tolerance analysis methods at Lockheed Martin Aeronautical Systems (LMAS). This paper describes the methods of analysis, which will be used to predict the effect of multiple site damage (MSD) cracks on the residual strength of WFD-susceptible locations of the airframe. The STAGS finite element code is used to develop an enhanced engineering approach for calculating the lead crack and MSD crack link-up stresses in ductile alloys. This approach involves using the crack tip opening angle (CTOA) as a criteria for crack extension in STAGS models of various multiple-crack configurations. to study the fastener load redistribution in lap splices containing lead and MSD cracks, detailed nonlinear solid element models were constructed using the Lockheed Martin DIAL finite element code. These lap joint models were run for numerous configurations of lead and MSD cracks, and show the effect of fastener load peaking and shedding as the lead crack approaches and emerges from MSD-cracked fastener holes. The results of these nonlinear calculations are used to develop a code for residual strength, based on crack link-up (using the enhanced engineering approach) when the linear-elastic stress intensity solution is known from detailed models of more complex wing and fuselage structure.
Author
Residual Strength; Structural Analysis; Fatigue (Materials); Damage; Cracks; Finite Element Method; Crack Propagation; Airframes; Skin (Structural Member)

19990028726 Air Force Research Lab., Wright-Patterson AFB, OH USA
Fatigue Crack Growth Predictions in Riveted Joints
Fawaz, S. A., Air Force Research Lab., USA; Schijve, J., Technische Univ., Netherlands; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 437-451; In English; See also 19990028721; No Copyright; Avail: CASI; A03, Hardcopy; A06, Microfiche

A characteristic aspect of fatigue of riveted lap joints is the occurrence of crack growth under a complex stress system, which in its simplest form consists of cyclic tension with superimposed cyclic bending due to the eccentricity in the lap joint. In reality, rivet squeezing leads to hole expansion and built-in residual stresses. In the empirical part of the investigation a simpler problem was analyzed first, i.e. fatigue crack growth in a multiple-hole sheet specimen loaded under combined tension and bending stress. Crack growth development for small part-through cracks could be followed by fractographic observations employing marker load cycles in between constant-amplitude loading. The same marking technique was employed for a simple lap joint having two rivet rows with four rivets in each row. The crack growth history could be reconstructed from a crack length of 75 microns to final fracture at 12 mm. In the analytical part, the well-known Newman-Raju K-solutions are available for part-through cracks. After through cracks are obtained they continue to grow with oblique crack fronts due to the combined tension and bending. Since no K-solutions are available for these cracks, the finite-element method and a three dimensional virtual crack closure technique (3D VCCT) were adopted. K-solutions for the crack shapes obtained in the open hole sheet specimen lap joint experiments are then calculated and adopted for the prediction of the growth of these cracks. A satisfactory agreement has been obtained. K-values have been calculated for a range of crack depth to crack length ratios, crack depth to sheet thickness ratios, and hole radius to sheet thickness ratios. The Newman/Raju K-solutions and newly calculated K-solutions for the through cracks have been incorporated into a crack growth prediction scheme. The prediction algorithm not only predicts the fatigue life within 6% of the actual life, but also accurately predicts the crack growth history until just prior to final fracture.
Author
Riveted Joints; Lap Joints; Fatigue (Materials); Crack Propagation; Crack Geometry; Finite Element Method; Structural Analysis; Fuselages

19990028728 Georgia Tech Research Inst., Atlanta, GA USA

Quantifying Spectrum Loading Effects on Fatigue Crack Growth

Zion, H. Lewis, Georgia Tech Research Inst., USA; Johnson, W. Steven, Georgia Inst. of Tech., USA; Ball, Dale L., Lockheed Martin Tactical Aircraft Systems, USA; Everett, Richard A., Jr., Army Vehicle Structures Lab., USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 462-471; In English; See also 19990028721; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

The combined effects of four variables on calculated spectrum fatigue crack growth (FCG) were compared using an experimental design approach (NASGRO 3.0 adaptation). The four parameters which were considered were: (1) load interaction, (2) load sequence (rainflow counted low-to-high, rainflow counted and randomized, and rainflow counted high-to-low), (3) crack tip stress state (plane stress versus plane strain) and (4) spectrum type (FELIX-28 helicopter rotor blade spectrum versus F-16 wing root bending moment spectrum). Each of the three load interaction models available in NASGRO 3.0 was used to compute load interaction effects. The investigation concluded that the order of cycles and crack tip constraint play relatively minor roles in computed FCG for problems involving repeated application of either of the given spectra, while the effects of the spectrum type itself, inclusion of load interaction effects and the synergy of spectrum with load interaction are highly significant.

Author

Load Tests; Crack Propagation; Aircraft Structures; Fatigue (Materials); Stress Cycles

19990028729 Boeing Information, Space and Defense Systems, Wichita, KS USA

Analytic Framework for Assessment of Corrosion and Fatigue in Fuselage Lap Joint

Cope, Dale A., Boeing Information, Space and Defense Systems, USA; Johnson, Patrick S., Boeing Information, Space and Defense Systems, USA; Trego, Angela, Boeing Information, Space and Defense Systems, USA; West, J. Doug, Boeing Information, Space and Defense Systems, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 472-481; In English; See also 19990028721; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

This paper discusses the development and demonstration of the Corrosion Damage Assessment Framework (CDAF). Two specific concerns that could affect safety limits for aging aircraft are the effects of corrosion damage and widespread fatigue damage (WFD) on structural integrity. This project evaluated the capabilities of several advanced analysis tools for assessing these effects on the structural integrity of riveted lap joints. In constructing the framework, Boeing evaluated existing structural analysis tools capable of performing stress analysis, fatigue crack propagation analysis, and structural failure risk assessment. to validate the tools, analyses were conducted on and compared to experimental test data from a previous research effort. This paper summarizes the tools and procedures used in the analytical framework and the analysis results of the experimental test. Under the CDAF project, the advanced structural analysis tools that were evaluated included: (1) Finite-element code, FRANC2D/L for determining stress distributions and stress intensity factors of cracks; (2) Crack growth analysis code, AFGROW, for estimating fatigue crack growth life; and (3) Risk analysis code, PROF, for determining the probability of fracture. The framework outlines the approaches used to provide the input data for each analytical tool, the procedures required to accomplish the analyses, and the processes to transfer data between the various analytical tools. These existing structural analysis tools were evaluated for their capabilities to address crevice corrosion and multiple site damage (MSD) associated with WFD in fuselage lap joints. to validate the analysis tools, one of the case studies performed compared analysis results to experimental test data on lap joint coupon specimens with and without corrosion. The evaluations investigated the tools' capabilities to account for two primary effects of crevice corrosion - material thinning and corrosion pillowing- and for two primary effects of WFD - MSD cracks and small cracks (cracks less than 0.05-in). The tools demonstrated the capabilities to perform stress analysis, crack growth analysis, and risk analysis on thin structural components with multiple layers of material and multiple cracks. Analysis results showed good agreement between predicted and experimental fatigue life for both the baseline and corroded configurations. Evaluations showed that analysis tools could account for material thinning and MSD cracks, but limitations in some of the tools prevented a complete evaluation that accounted for corrosion pillowing or small cracks. With further improvements in analysis tools and techniques, the analytical framework would be useful in assessing the impact of corrosion damage and MSD on the integrity of an aircraft structural component.

Author

Damage Assessment; Fatigue (Materials); Fuselages; Lap Joints; Structural Analysis; Finite Element Method; Crack Propagation; Cavitation Corrosion

19990028730 CC Technologies Labs., Inc., Dublin, OH USA

Mathematical Model to Predict Fatigue Crack Initiation in Corroded Lap Joints

Koch, Gerhardus H., CC Technologies Labs., Inc., USA; Yu, Le, Ohio State Univ., USA; Katsube, Noriko, Ohio State Univ., USA; Paul, Clare A., Air Force Research Lab., USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 482-492; In English; See also 19990028721; No Copyright; Avail: CASI; A03, Hardcopy; A06, Microfiche

There is increasing concern about the possible detrimental effects of corrosion on the structural integrity of fuselage lap joints. Corrosion in lap joints can lead to a decrease in strength because of loss in skin thickness, early fatigue crack initiation caused by the formation of stress risers, and increased fatigue crack growth rates. The mode of corrosion in lap joints has generally been considered to be uniform loss of material. Based on the concept of general thickness loss and the formation of voluminous corrosion products as a result of exfoliation corrosion, models to predict the stress distribution and fatigue crack initiation sites have been previously developed. These models indicate that that the combination of loss in skin thickness and the build up of voluminous corrosion products inside the lap joint will lead to high stresses in the joint where fatigue cracks are likely to initiate. However, these calculations are not based on the actual morphology of corrosion in the lap joint. In this paper, detailed metallography of a KC-135 lap-joint section describes the complex nature of corrosion on the contact or faying surface, with barely detectable corrosion penetrating deep into the skin. A finite element model was developed, based on the actual corrosion morphology of the lap joint. The finite element program ABAQUS was used to model the strain/stress distribution in a corroded lap-joint section. The corrosion was simulated by decreasing the skin thickness and applying a uniform pressure to represent the build up of corrosion by-products. A small hemisphere was introduced to simulate the localized intergranular corrosion. The results of the finite element analysis demonstrated that even a small hemispherical indent superimposed on uniform type corrosion near a fastener hole resulted in significant increase in elastic strain such that early fatigue crack initiation could be anticipated.

Author

Mathematical Models; Fatigue (Materials); Crack Propagation; Lap Joints; Fuselages; Intergranular Corrosion; Finite Element Method; Structural Analysis

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Analytical and Test Evaluations on the Linkup of Multiple Cracking in Stiffened Fuselage Panels

Jeong, David Y., Department of Transportation, USA; Bakuckas, John G., Jr., Hughes Technical Center, USA; Samavedam, Gopal, Foster-Miller Associates, Inc., USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 493-502; In English; See also 19990028721; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

This paper describes testing and analysis of stiffened curved fuselage panels containing multiple cracks. Testing was conducted on a fabricated panel with various cracking configurations. The typical cracking scenario was a main lead crack with multiple smaller collinear cracks. Engineering analyses were conducted to predict the remote stress at linkup. These analyses were carried out with a displacement compatibility model in conjunction with analytically derived expressions for the bulging factor. The expression for the bulging factor included empirical constants which were determined from curve fitting of finite element results. Estimates for linkup are based on assuming that linkup occurs from plastic collapse of ligaments between adjacent crack-tips. The engineering analyses provided reasonable but conservative estimates for the remote stress at linkup, in most cases (i.e., the predicted values were lower than the experimental values). In general, the predicted linkup stresses are within 25% of the experimentally measured values. Further work is needed to improve the accuracy of the approach used in this paper, particularly in validating the effect of bulging in pressurized stiffened curved panels.

Author

Fuselages; Curved Panels; Crack Propagation; Finite Element Method; Structural Analysis

19990028732 Alcoa Technical Center, Alcoa Center, PA USA

Benefits of Improved Fuselage Skin Sheet Alloy 2524-T3 in Multi-Site Damage Scenarios

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This paper quantifies the improved resistance to the consequences of multi-site damage (MSD) that can develop in older aircraft provided by new Alcoa aluminum fuselage skin sheet alloy 2524-T3. Results from three types of tests are presented for 2524-T3 and the incumbent fuselage skin sheet alloy 2024-T3: (1) residual strength tests to assess the effect of multi-site damage on residual strength of unstiffened and stiffened flat panels; (2) fatigue tests on unstiffened flat panels to assess the effects of multi-site damage on fatigue life; and (3) fatigue tests on multi-hole coupons with and without prior corrosion to evaluate the resistance of each alloy to naturally occurring MSD. The results indicate that alloy 2524 offers improved structural damage tolerance in the presence of MSD due to its superior fatigue crack growth resistance and fracture toughness and is more resistant to MSD from corrosion in bare sheet form. The residual strength of 2524 panels containing a lead crack with MSD at adjacent holes was 8.8 to 10.4% higher than 2024 panels and the average fatigue life 27 to 45% longer depending on MSD flaw size. The two alloys had equivalent resistance to MSD from fatigue alone but the mean flaw areas following corrosion and fatigue were 18% smaller in

bare 2524 than in bare 2024 and the corroded area alone 32% smaller. Potential advantages of the improved damage tolerance of 2524-T3 to aircraft manufacturer/operators are weight savings, lower operating costs, easier inspectability and increased safety.
Author
Aluminum Alloys; Fuselages; Residual Strength; Fatigue Tests; Crack Propagation; Damage; Structural Analysis; Corrosion Resistance; Skin (Structural Member)

19990028733 NASA Langley Research Center, Hampton, VA USA
Fracture Analysis of the FAA/NASA Wide Stiffened Panels
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This paper presents the fracture analyses conducted on the FAA/NASA stiffened and unstiffened panels using the STAGS (STructural Analysis of General Shells) code with the critical crack-tip-opening angle (CTOA) fracture criterion. The STAGS code with the "plane-strain" core option was used in all analyses. Previous analyses of wide, flat panels have shown that the high-constraint conditions around a crack front, like plane strain, has to be modeled in order for the critical CTOA fracture criterion to predict wide panel failures from small laboratory tests. In the present study, the critical CTOA value was determined from a wide (unstiffened) panel with anti-buckling guides. The plane-strain core size was estimated from previous fracture analyses and was equal to about the sheet thickness. Rivet flexibility and stiffener failure was based on methods and criteria, like that currently used in industry. STAGS and the CTOA criterion were used to predict load-against-crack extension for the wide panels with a single crack and multiple-site damage cracking at many adjacent rivet holes. Analyses were able to predict stable crack growth and residual strength within a few percent (5%) of stiffened panel tests results but over predicted the buckling failure load on an unstiffened panel with a single crack by 10%.
Author
Fracture Mechanics; Structural Analysis; Applications Programs (Computers); Crack Propagation; Residual Strength; Finite Element Method; Aircraft Structures

19990028734 Wichita State Univ., Dept. of Aerospace Engineering, Wichita, KS USA
Improved Engineering Methods for Determining The Critical Strengths of Aluminum Panels with Multiple Site Damage in Aging Aircraft
Smith, Bert, Wichita State Univ., USA; Mouak, Adil, Wichita State Univ., USA; Saville, Perry, Wichita State Univ., USA; Myose, Roy, Wichita State Univ., USA; Horn, Walter, Wichita State Univ., USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 525-534; In English; See also 19990028721; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

An aging aircraft accumulates widespread fatigue damage commonly referred to as multiple site damage (MSD). For ductile materials such as 2024-T3 aluminum, MSD may lower the critical (residual) strength below that which is predicted by conventional fracture mechanics. An analytical model generally referred to as the linkup model (or the plastic zone touch model) has previously been used to describe this phenomenon. However, the linkup model has been shown to produce inaccurate results for many configurations. This paper describes two modifications of the linkup model that have been shown to predict accurate results over a wide range of configurations for both unstiffened and stiffened flat 2024-T3 panels with MSD at open holes.
Author
Aircraft Structures; Aluminum Alloys; Fatigue (Materials); Mathematical Models; Residual Strength; Damage; Fracture Mechanics

19990028735 National Research Council of Canada, Structures, Materials and Propulsion Lab., Ottawa, Ontario Canada
Corrosion Pillowing Cracks in Fuselage Joints
Bellinger, Nicholas C., National Research Council of Canada, Canada; Komorowski, Jerzy P., National Research Council of Canada, Canada; Gould, Ron W., National Research Council of Canada, Canada; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 535-544; In English; See also 19990028721; Sponsored in part by; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

In a previous study carried out at the National Research Council Canada, pillowing in a fuselage lap joint caused by the presence of corrosion products was shown to result in a stress gradient through the skin thickness. This gradient led to a very high stress along the faying surface of the outer skin and a decreased stress on the outer surface. Consequently, it was shown that corrosion pillowing could cause the formation of semi-elliptical cracks with a high aspect ratio. In recent tear-down inspections, these types

of cracks have been found on the faying surfaces of disassembled corroded circumferential and longitudinal lap joints. These joints were obtained from both retired and operational aircraft. The majority of the cracks discovered had not penetrated through to the surface, although some had lengths in excess of 6.35 mm (0.25 in.). All the fracture surfaces showed extensive intergranular cracking with numerous secondary cracks. Fatigue striations were observed on some of the crack surfaces. None of the cracks were found using conventional nondestructive inspection techniques typically used for lap splice inspection.
Author
Fuselages; Lap Joints; Structural Analysis; Cracks; Skin (Structural Member); Corrosion

19990028736 Cambridge Univ., Engineering Dept., Cambridge, UK
Towards a Predictive Design Methodology for Composite Laminate Patches Based on Physical Modeling of Failure Processes
Beaumont, Peter W. R., Cambridge Univ., UK; Greer, James M., Jr., Air Force Academy, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 545-554; In English; See also 19990028721; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

A predictive design methodology has been developed for composite materials and structures based explicitly on analytical models of the physical processes (phenomena) by which damage accumulates. This methodology has been successfully applied to a variety of advanced strategic composite material systems. The effects of environment, temperature, and moisture, for instance, are also included in this modeling strategy. It would be desirable to reformulate this phenomena-based micromechanics model for application to composite-bonded repairs of metallic structures. This reformulation would allow the model to be applied to (1) empirical models of composite patch behavior (to provide a predictive capability), (2) existing finite element models (to ensure the widest possible utility to the design and application of composite patches to cracked aircraft structures), and (3) the design of software, including existing material and patch optimization codes (to aid implementation at all stages of the predictive design process and application). The major objective is to successfully apply this physical model of damage growth in a format suitable for the predictive design of notch-insensitive, damage tolerant composite-metal patch systems for application in hostile environments, including extremes of temperature. It is the intent that the form of these models will be suitable for incorporating into existing design software, e.g., as a constitutive law sub-routine for a finite element code and a sub-routine of an optimization code for patch design. This paper describes and assesses this design methodology as it has been applied to composites, and suggests how it might be applied to the technology of composite repairs to metallic structures.
Author
Aircraft Structures; Composite Materials; Mathematical Models; Micromechanics; Prediction Analysis Techniques; Cumulative Damage; Laminates; Design Analysis

19990028737 Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Inst. of Materials Research, Cologne, Germany
A CTOD Approach to Assess Stable Tearing Under Complex Loading Conditions
Donne, Claudio Dalle, Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Germany; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 555-564; In English; See also 19990028721; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

An engineering approach for assessing the ductile fracture of cracked thin structures based on the delta(sub 5) crack tip opening displacement (ctod) is presented. Standard laboratory tests and experiments with biaxially loaded cruciform specimens of 6 mm thick 2024-T3 sheets showed that the delta(sub 5)-R-curves were reasonably independent of specimen geometry and applied loading conditions over almost the entire testing range. This was also found for inclined pre-cracks (mixed-mode I/II) and small cracks emanating from notches under biaxial loading. Only negative biaxial loading ratios, which lowered dramatically the constraint of plastic deformation ahead of the crack tip, led to an apparent increase of crack resistance. These constraint effects could however be quantified through a second parameter based on the linear elastic T-stress. The driving force was estimated with the Engineering Treatment Method (ETM), which required only the stress intensity factor and plastic limit load solutions of the considered structure as well as the material stress and strain power law as input parameters. The ETM predictions of delta(sub 5)-driving force were compared to the experimentally measured ctod values.
Author
Crack Tips; Ductility; Fracturing; Tearing; Crack Opening Displacement; Cracking (Fracturing); Mathematical Models; Aircraft Structures

19990028738 NASA Langley Research Center, Hampton, VA USA

Residual Strength Predictions with Crack Buckling

Dawicke, D. S., NASA Langley Research Center, USA; Gullerud, A. S., Illinois Univ., USA; Dodds, R. H., Jr., Illinois Univ., USA; Hampton, R. W., NASA Ames Research Center, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 565-574; In English; See also 19990028721; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

Fracture tests were conducted on middle crack tension, M(T), and compact tension, C(T), specimens of varying widths, constructed from 0.063 inch thick sheets of 2024-T3 aluminum alloy. Guide plates were used to restrict out-of-plane displacements in about half of the tests. Analyses using the three-dimensional, elastic-plastic finite element code WARP3D simulated the tests with and without guide plates using a critical CTOA fracture criterion. The experimental results indicate that crack buckling reduced the failure loads by up to 40%. Using a critical CTOA value of 5.5 deg., the WARP3D analyses predicted the failure loads for the tests with guide plates within +/- 10% of the experimentally measured values. For the M(T) tests without guide plates, the WARP3D analyses predicted the failure loads for the 12 and 24 inch tests within 10%, while over predicting the failure loads for the 40 inch wide tests by about 20%.

Author

Buckling; Residual Strength; Finite Element Method; Failure Analysis; Structural Analysis; Aircraft Structures; Crack Tips; Cracking (Fracturing); Crack Opening Displacement; Applications Programs (Computers); Mathematical Models

19990028739 NASA Langley Research Center, Hampton, VA USA

A Mixed-Mode I/II Fracture Criterion and Its Application in Crack Growth Predictions

Sutton, Michael A., South Carolina Univ., USA; Deng, Xiaomin, South Carolina Univ., USA; Ma, Fashang, South Carolina Univ., USA; Newman, James S., Jr., NASA Langley Research Center, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 575-583; In English; See also 19990028721; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

A crack tip opening displacement (CTOD)-based, mixed mode fracture criterion is developed for predicting the onset and direction of crack growth. The criterion postulates that crack growth occurs in either the Mode I or Mode II direction, depending on whether the maximum in either the opening or the shear component of CTOD, measured at a specified distance behind the crack tip, attains a critical value. For crack growth direction prediction, the proposed CTOD criterion is shown to be equivalent to seven commonly used crack growth criteria under linearly elastic and asymptotic conditions. Under elastic-plastic conditions the CTOD criterion's prediction of the dependence of the crack growth direction on the crack-up mode mixity is in excellent agreement with the Arcan test results. Furthermore, the CTOD criterion correctly predicts the existence of a crack growth transition from mode I to mode II as the mode mixity approaches the mode II loading condition. The proposed CTOD criterion has been implemented in finite element crack growth simulation codes Z1P2DL and FRANC2DL to predict the crack growth paths in (a) a modified Arcan test specimen and fixture made of AL 2024-T34 and (b) a double cantilever beam (DCB) specimen made of AL 7050. A series of crack growth simulations have been carried out for the crack growth tests in the Arcan and DCB specimens and the results further demonstrate the applicability of the mixed mode CTOD fracture criterion crack growth predictions and residual strength analyses for airframe materials.

Author

Computerized Simulation; Crack Propagation; Fracturing; Crack Opening Displacement; Applications Programs (Computers); Finite Element Method; Airframe Materials

19990028740 Aeronautical Research Inst. of Sweden, Bromma, Sweden

Yield Strip Models for Residual Strength of MSD Damaged Curved and Flat Panels

Nilsson, Karl-Frederik, Aeronautical Research Inst. of Sweden, Sweden; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 584-597; In English; See also 19990028721

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The paper presents a yield-strip model to compute the residual strength of structures damaged by multiple site damage (MSD) and two particular applications. The first presents a parameter study of a stiffened sheet where the influence of crack patterns, and crack sizes and crack growth resistance are investigated. This study showed that the residual strength reduction was more pronounced for crack growth resistant materials, that also very small cracks may have a large impact and that cracking at tear straps is particularly deleterious. The second applications concerned an analysis of a cylindrical shell where nonlinear bulge-out is

accounted for. The residual strength was compared with corresponding flat sheet results. The stress levels for the shelf are two to three times lower due to bulge out, but the relative reduction due to MSD was very similar.
Author
Residual Strength; Fracture Strength; Mathematical Models; Crack Propagation; Crack Geometry; Computerized Simulation; Aircraft Structures; Structural Analysis

19990028741 Drexel Univ., Dept. of Materials Engineering, Philadelphia, PA USA
Boundary Connection Factors for Elliptical Surface Cracks Emanating from Countersunk Rivet Holes
Rahman, Anisur, Drexel Univ., USA; Bakuckas, John G., Jr., Hughes Technical Center, USA; Bigelow, Catherine A., Hughes Technical Center, USA; Tan, Paul W., Hughes Technical Center, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 598-609; In English; See also 19990028721
Contract(s)/Grant(s): FAA-97-G-026; MSS960013P; No Copyright; Avail: CASI; A03, Hardcopy; A06, Microfiche

To predict crack growth and residual strengths of riveted joints subjected to widespread fatigue damage (WFD), accurate stress and fracture analyses of corner and surface cracks at a rivet hole are needed. The results presented in this paper focus on the computation of stress-intensity factor (SIF) solutions for cracks at countersunk rivet holes for tension, bending, and wedge load conditions. A wide range of configurations was considered varying the crack size, crack shape, crack location, and the height of the straight-shank hole. A global-intermediate-local (GIL) hierarchical approach implementing the finite element method was used in this study. The GIL approach was used to determine the boundary correction factors, a nondimensional representation of the SIF, for a wide range of configurations representing typical countersunk holes in aircraft structural joints. The boundary correction factor was determined along the crack front in terms of the physical angle measured from the inner surface of the plate to the boundary of the countersunk rivet hole. In general, the values of boundary correction factors increased as the location along the crack front moves from the inner surface of the plate towards the hole boundary. For all the crack locations analyzed, the inner surface of the plate has less of an influence on the boundary correction factor than the hole and outer surface boundaries. The values of the boundary correction factor were highest for the crack fronts closest to the hole boundary. The trends in the solutions were the same for the three loading conditions.
Author
Crack Propagation; Holes (Mechanics); Riveted Joints; Stress Intensity Factors; Surface Cracks; Residual Strength; Damage; Aircraft Structures; Boundary Conditions; Crack Geometry; Finite Element Method

19990028742 NASA Langley Research Center, Hampton, VA USA
Stable Tearing and Buckling Responses of Unstiffened Aluminum Shells with Long Cracks
Starnes, James H., Jr., NASA Langley Research Center, USA; Rose, Cheryl A., NASA Langley Research Center, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 610-626; In English; See also 19990028721; No Copyright; Avail: CASI; A03, Hardcopy; A06, Microfiche

The results of an analytical and experimental study of the nonlinear response of thin, unstiffened, aluminum cylindrical shells with a long longitudinal crack are presented. The shells are analyzed with a nonlinear shell analysis code that accurately accounts for global and local structural response phenomena. Results are presented for internal pressure and for axial compression loads. The effect of initial crack length on the initiation of stable crack growth and unstable crack growth in typical shells subjected to internal pressure loads is predicted using geometrically nonlinear elastic-plastic finite element analyses and the crack-tip-opening angle (CTOA) fracture criterion. The results of these analyses and of the experiments indicate that the pressure required to initiate stable crack growth and unstable crack growth in a shell subjected to internal pressure loads decreases as the initial crack length increases. The effects of crack length on the prebuckling, buckling and postbuckling responses of typical shells subjected to axial compression loads are also described. For this loading condition, the crack length was not allowed to increase as the load was increased. The results of the analyses and of the experiments indicate that the initial buckling load and collapse load for a shell subjected to axial compression loads decrease as the initial crack length increases. Initial buckling causes general instability or collapse of a shell for shorter initial crack lengths. Initial buckling is a stable local response mode for longer initial crack lengths. This stable local buckling response is followed by a stable postbuckling response, which is followed by general or overall instability of the shell.
Author
Dynamic Response; Cylindrical Shells; Finite Element Method; Crack Propagation; Crack Tips; Crack Initiation; Applications Programs (Computers); Cracking (Fracturing); Fuselages; Elastic Buckling; Dynamic Models

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Fracture Mechanics of Thin, Cracked Plates Under Tension, Bending and Out-of-Plane Shear Loading

Zehnder, Alan T., Cornell Univ., USA; Hui, C. Y., Cornell Univ., USA; Potdar, Yogesh, Cornell Univ., USA; Zucchini, Alberto, Energia Nucleare e Delle Energie Alternative, Italy; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 627-634; In English; See also 19990028721

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Cracks in the skin of aircraft fuselages or other shell structures can be subjected to very complex stress states, resulting in mixed-mode fracture conditions. For example, a crack running along a stringer in a pressurized fuselage will be subject to the usual in-plane tension stresses (Mode-I) along with out-of-plane tearing stresses (Mode-III like). Crack growth and initiation in this case is correlated not only with the tensile or Mode-I stress intensity factor, K(sub I), but depends on a combination of parameters and on the history of crack growth. The stresses at the tip of a crack in a plate or shell are typically described in terms of either the small deflection Kirchhoff plate theory. However, real applications involve large deflections. We show, using the von-Karman theory, that the crack tip stress field derived on the basis of the small deflection theory is still valid for large deflections. We then give examples demonstrating the exact calculation of energy release rates and stress intensity factors for cracked plates loaded to large deflections. The crack tip fields calculated using the plate theories are an approximation to the actual three dimensional fields. Using three dimensional finite element analyses we have explored the relationship between the three dimensional elasticity theory and two dimensional plate theory results. The results show that for out-of-plane shear loading the three dimensional and Kirchhoff theory results coincide at distance greater than h/2 from the crack tip, where h/2 is the plate thickness. Inside this region, the distribution of stresses through the thickness can be very different from the plate theory predictions. We have also explored how the energy release rate varies as a function of crack length to plate thickness using the different theories. This is important in the implementation of fracture prediction methods using finite element analysis. Our experiments show that under certain conditions, during fatigue crack growth, the presence of out-of-plane shear loads induces a great deal of contact and friction on the crack surfaces, dramatically reducing crack growth rate. A series of experiments and a proposed computational approach for accounting for the friction is discussed.

Author

Crack Propagation; Crack Tips; Fracture Mechanics; Fuselages; Plate Theory; Crack Initiation; Bending; Tensile Stress; Shear Stress; Structural Analysis; Surface Cracks

19990028744 Cornell Univ., Fracture Group, Ithaca, NY USA

Residual Strength Prediction of Fuselage Structures with Multiple Site Damage

Chen, Chuin-Shan, Cornell Univ., USA; Wawrzynek, Paul A., Cornell Univ., USA; Ingraffea, Anthony R., Cornell Univ., USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 635-656; In English; See also 19990028721

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This paper summarizes recent results on simulating full-scale pressure tests of wide body, lap-jointed fuselage panels with multiple site damage (MSD). The crack tip opening angle (CTOA) fracture criterion and the FRANC3D/STAGS software program were used to analyze stable crack growth under conditions of general yielding. The link-up of multiple cracks and residual strength of damaged structures were predicted. Elastic-plastic finite element analysis based on the von Mises yield criterion and incremental flow theory with small strain assumption was used. A global-local modeling procedure was employed in the numerical analyses. Stress distributions from the numerical simulations are compared with strain gage measurements. Analysis results show that accurate representation of the load transfer through the rivets is crucial for the model to predict the stress distribution accurately. Predicted crack growth and residual strength are compared with test data. Observed and predicted results both indicate that the occurrence of small MSD cracks substantially reduces the residual strength. Modeling fatigue closure is essential to capture the fracture behavior during the early stable crack growth. Breakage of a tear strap can have a major influence on residual strength prediction.

Author

Residual Strength; Fuselages; Full Scale Tests; Lap Joints; Crack Opening Displacement; Applications Programs (Computers); Stress Distribution; Computerized Simulation; Finite Element Method; Mathematical Models; Fracture Mechanics

19990028746 Sikorsky Aircraft, Airframe Structures, Stratford, CT USA

A Comparison of Numerical Methods of Fracture Analysis with Helicopter Structure

Bauer, George V., Sikorsky Aircraft, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 667-678; In English; See also 19990028721; No Copyright; Avail: CASI; A03, Hardcopy; A06, Microfiche

This Paper provides the results of an investigation of two numerical methods for calculation of stress intensity and crack growth for through thickness cracks in complex structures. The two numerical methods are the NASTRAN two dimensional crack tip finite element CRAC2D and the Surface Integral and Finite Element (SAFE) hybrid analysis. The basis and applicability of each method is discussed, and comparison is made with standard through thickness crack handbook solutions. The application of these methods to crack growth analysis in a typical helicopter airframe structure is evaluated.
Author
Applications Programs (Computers); Airframes; Crack Propagation; Nastran; Structural Analysis; Fracture Mechanics; Finite Element Method; Mathematical Models

19990028747 Lehigh Univ., Dept. of Mechanical Engineering and Mechanics, Bethlehem, PA USA
Importance of Chemically Short-Crack-Growth on Fatigue Life
Dolley, Evan J., Lehigh Univ., USA; Wei, Robert P., Lehigh Univ., USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 679-687; In English; See also 19990028721
Contract(s)/Grant(s): F49620-96-1-0245; F49620-98-1-0198; FAA-92-G-0006; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

Commercial and military aircraft are exposed to deleterious environments (such as atmospheric moisture and salt spray) that enhance the fatigue crack-growth (FCG) rates in aircraft structural components. This phenomenon, generically termed corrosion fatigue (CF) must be explicitly taken into account in the development of life prediction and management methodology. CFCG behavior may be separated into two regimes: a chemically long-crack regime and a chemically short-crack regime. Experimental data on aluminum alloys used in aircraft construction show that the CFCG rates are up to 10 times that in an inert environment in the long-crack regime. In the chemically short regime, the growth rates are further enhanced by up to a factor of three, with the effect extending out to crack lengths of up to 6 mm. The accelerated CFCG rates in the short-crack regime must be considered since they can affect crack-growth, for example, over nearly one-half of the inter-rivet distance in typical fuselage lap-splice joints. Crack-growth results on 2024-T3 and 7075-T6 aluminum alloys are presented and compared. The implication of the chemically short-crack-growth regime on fatigue life is discussed.
Author
Crack Propagation; Short Cracks; Aircraft Structures; Aluminum Alloys; Fatigue Life; Structural Analysis

19990028748 Aero Vodochody A.S., Odolena Voda, Czechoslovakia
Composite Coating of Jet Engine Air Intake as a Protection Against Acoustic Fatigue
Fidransky, Jiri, Aero Vodochody A.S., Czechoslovakia; Fiala, Jiri, Aero Vodochody A.S., Czechoslovakia; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 688-696; In English; See also 19990028721; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

The Aero Vodochody L59 advanced jet trainer is powered by DV2 engine with the trust of 4900 lb. A significant damage of air intake was caused by sonic fatigue after a very short time of aircraft prototype testing. Original design of air intake was made as a sheet formed riveted aluminum structure. Initial damage, such as stiffener cracks and broken rivets, occurred after 50 hours of engine run. Acoustic loading was analyzed afterwards and significant load of almost 160 dB was found. Based on previous experience we assumed that existing structure was not able to withstand acoustic pressures of such level, mostly concentrated on frequency of 3 kHz. Having in mind natural fatigue limits of aluminum structures, removable part of air intake was replaced for modified one. Driving force of modification was an idea of durable and easy to change structure, with better damping. Engine inlet part was substituted for stiffer ring, made of high strength steel, cylindrical part of air passage was replaced by carbon fibre monolithic structure of outstanding durability, but bifurcated air duct as a part of the fuselage structure was difficult to change. This part is fully integrated into the fuselage load path and proposed material change to carbon fibre composite structure was not feasible. When structural response of fatigue critical areas was analyzed, existing metallic structure, coated with glass and carbon fibre composite as all surface doublers has been proposed as the most suitable solution. Main design goals were to lower stresses in existing fuselage structure, to improve structural damping, to reduce stress concentration and to use material with the best available fatigue characteristic. Final design consists of metal sheet with stacked layers of woven glass and carbon fibres in Epoxy matrix. Composite layers were impregnated, bonded to supporting structure and cured in single cycle. Sophisticated stacking up improved stiffness, structural damping and reduced thermal induced stresses between adjacent layers into acceptable level. Hybrid wall structure was designed so as to be tolerant to accidental damage or to interlaminar cracks. Therefore, a very extensive qualification process took place, but major problems, we were faced with concern environmental resistance of composite to metal bonding, resistance to thermal induced stresses and full scale verification of service efficiency. Several hundreds of coupons were tested during qualification process. Final proof of structure was given by in service measurement. The lot production of composite air intake coat required building up a special shop. At the beginning of nineties, about 70 air intakes of L59 aircraft were treated. Total

covered surface was about 45 square feet per one aircraft. All aircraft have been in service for about 6 years. There have been no service reported difficulties regarding composite coat of air duct, their wear or damage. The same treatment seems to be effective for any acoustic loaded air passages or heavy loaded open surfaces.
Author
Protective Coatings; Composite Materials; Air Intakes; Acoustic Fatigue; High Strength Steels; Epoxy Matrix Composites; Fiber Composites; Dynamic Structural Analysis

19990028749 Bombardier, Inc., Mirabel, Quebec Canada
CF-18 Inner Wing Front Spar Cracking
Francoeur, Yvan, Bombardier, Inc., Canada; Adam, Daniel, Bombardier, Inc., Canada; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 697-706; In English; See also 19990028721; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

Cracks at various holes on the Canadian CF-18 Inner Wing Front Spar (P/N 74A110604) near the Inboard Leading Edge Flap (ILEF) Drive Hinge were detected. The most cost effective modification for this location involve either coldwork, forcemate or IF bushing. The critical holes are all located in a seal groove therefore the spar can only be reworked on 70% of its thickness. In addition, the holes are separated 1.0 inch apart so residual stresses of the coldwork and forcemate process super-impose at the center of the two holes. In this situation, available fatigue analysis produces highly questionable results. A fatigue coupon test is therefore required. The finite element analysis performed to evaluate the residual stress of each process and define the adequate test specimen geometry is presented. An experimental substantiation of the FE results will follow. Finally a brief discussion of the coupon test is provided.
Author
Cracking (Fracturing); Residual Stress; Structural Members; Aircraft Structures; Structural Analysis; Finite Element Method; Stress Analysis

19990028750 APR Consultants, Inc., Medway, OH USA
Reduction in Fatigue Damage Incurred During Ground Operations on Rough Runways
Gerardi, Tony, APR Consultants, Inc., USA; Tritsch, Doug, Dayton Univ. Research Inst., USA; Knarr, Robert, Knarr (Robert), USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 707-715; In English; See also 19990028721; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

The combination of expanded usage, extended service life, and fiscal constraints has led to a focus on the technologies which support the structural integrity of aging aircraft. The aim is to reduce the support and sustainment burdens of these aging aircraft. This includes safely extending the useful service life of an airframe by reducing the fatigue damage accumulation rates. Reducing the number of damaging events or the magnitude of some damaging events will mitigate the fatigue damage accumulation. The results from this effort offers a concept that involves altering the landing gear service procedures to increase the strut precharge pressure. This non-intrusive technique will significantly reduce the dynamic loads experienced by an aircraft during takeoff. The fatigue life of an aircraft is based in part, on the number and magnitude of ground-air-ground (GAG) cycles the aircraft is expected to experience. Recall that the "ground" loads define the alternating portion of the GAG cycle. Fatigue crack initiation and growth rates are most influenced by changes in the alternating part of a damaging load cycle. Generally, the design has factored in dynamic loads experienced by the aircraft during takeoff, measured as accelerations at the center of gravity, (load factors). In particular, the negative load factors the overall GAG definition. It is important to recall that aircraft are designed for more positive g's than negative g's. However, it is not unusual to exceed 0.5 g on paved runways that have deteriorated with time and use. Consequently, operations on rough runways will reduce the life of the aircraft. The overall objective was to develop a practical method for estimating the extended airframe life by reducing loads due to ground operations on rough runways. The primary purpose was to determine the feasibility of the concept that increasing the landing gear strut precharge pressure is an adequate approach to achieving a reasonable reduction in the airframe loads. Investigations have shown that ground loads can cause airframe structural damage and is more prevalent than previously suspected. One example was an L-1011 found with a 24- inch long crack in a rear wing spar web at the main landing gear trunnion attachment. The results of this effort included: 1) Establishing that a 30% reduction in the magnitude of the load was achieved by increasing strut precharge pressure; 2) Validation with hydraulic shaker tests; and 3) A preliminary estimated fatigue life factor of 1.15, (15% life extension) achieved by reducing airframe loads due to rough runway ground loads. This poster presentation covers the efforts and results and describes the next step prior to implementation.
Author (revised)
Dynamic Loads; Landing Gear; Struts; Dynamic Pressure; Cumulative Damage; Load Distribution (Forces)

19990028752 Northrop Grumman Corp., El Segundo, CA USA
Composite Patch Repair Applications to T-38 Lower Wing Skin
Helbling, James, Northrop Grumman Corp., USA; Heimerdinger, Maro, Northrop Grumman Corp., USA; Ratwani, Mohan M., R-Tec, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 722-731; In English; See also 19990028721; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

A bonded composite reinforcement concept has been investigated for the T-38 aircraft as a means to retard crack initiation and crack growth occurring in a machined pocket area of the lower wing skin. A test program has been carried out to experimentally determine the crack growth life extension offered by the composite patch reinforcement and verify the patch design and analysis. Test specimens were designed to simulate the pocket area in the wing where cracking is occurring. Two specimens were tested under fighter spectrum loading. One specimen was tested without the reinforcement to obtain baseline crack growth data, and an identical specimen was tested with a 26 ply boron/epoxy patch bonded to one surface. The test specimens were strain gaged to obtain load distributions in the specimen and determine the amount of load transfer to the patch. The crack growth life of the specimen with the patch installed was found to be approximately twice that of the unreinforced specimen. The crack growth data obtained from the tests showed considerably longer crack growth life compared to the analytical predictions. This anomaly was apparently the result of the initial flaw being placed near the corner of the machined pocket, thus causing the crack to be retarded in the direction of increased skin thickness. Adjustments were made to the analytical model which allowed for a good correlation between the predicted crack growth and the test data.
Author
Crack Initiation; Crack Propagation; Skin (Structural Member); Aircraft Structures; Composite Materials

19990028753 College of William and Mary, Dept. of Applied Science, Williamsburg, VA USA
Lamb Wave Tomography for Corrosion Mapping
Hinders, Mark K., College of William and Mary, USA; McKeon, James C. P., College of William and Mary, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 732-740; In English; See also 19990028721; Sponsored in part by the Virginia Space Grant Consortium; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

As the world-wide civil aviation fleet continues to age, methods for accurately predicting the presence of structural flaws-such as hidden corrosion-that compromise airworthiness become increasingly necessary. Ultrasonic guided waves, Lamb waves, allow large sections of aircraft structures to be rapidly inspected. However, extracting quantitative information from Lamb wave data has always involved highly trained personnel with a detailed knowledge of mechanical-waveguide physics. Our work focuses on using a variety of different tomographic reconstruction techniques to graphically represent the Lamb wave data in images that can be easily interpreted by technicians. Because the velocity of Lamb waves depends on thickness, we can convert the travel times of the fundamental Lamb modes into a thickness map of the inspection region. In this paper we show results for the identification of single or multiple back-surface corrosion areas in typical aluminum aircraft skin structures.
Author
Ultrasonic Flaw Detection; Lamb Waves; Corrosion; Detection; Aircraft Structures; Tomography

19990028754 Analytical Services and Materials, Inc., Hampton, VA USA
Experimental Results from the FAA/NASA Wide Panel Fracture Tests
Johnston, William M., Analytical Services and Materials, Inc., USA; Helm, Jeffrey D., South Carolina Univ., USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 741-754; In English; See also 19990028721; No Copyright; Avail: CASI; A03, Hardcopy; A06, Microfiche

The objective of the FAA/NASA wide panel test program was to determine the influence of multiple-site damage (MSD) on the residual strength of stiffened and unstiffened panels and to develop a body of experimental data that can be used to verify any fracture criterion for structures with MSD cracking. To simulate an aircraft skin, tests were conducted on 40-inch wide panels of 0.063-inch thick 2024-T3 aluminum alloy with stiffeners that were made of 0.090-inch thick 7075-T6 aluminum alloy. The FAA/NASA wide panel tests were performed on panels with and without riveted stiffeners for five different crack configurations. The riveted stiffened panels were designed to provide a configuration similar to a riveted curved aircraft structure. The crack configurations tested were single crack, single crack growing into a line of open holes, and single crack growing into a line of open holes with MSD cracks. These test configurations simulated a long crack in the presence of a row of holes with and without MSD. Experimental results of the linkup, maximum load, local and global strain fields, deformation field and load crack extension behavior are presented in this paper. The MSD cause a 20% and 30% reduction in strength for the unstiffened and stiffened panels respec-

tively when compared to the center crack case. The MSD size (0.01 to 0.05 inch) did not significantly effect the reduction in strength caused by the MSD.
Author
Residual Strength; Destructive Tests; Cracking (Fracturing); Aircraft Structures; Skin (Structural Member); Crack Propagation; Aluminum Alloys; Structural Analysis

19990028755 Lynntech, Inc., College Station, TX USA
Novel NDE/I Probe for the Detection of Corrosion in Aircraft Metallic Structures Based on Electrochemical Impedance
Kim, Jinseong, Lynntech, Inc., USA; Gonzalez, Anuncia, Lynntech, Inc., USA; Hodko, Dalibor, Lynntech, Inc., USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 755-763; In English; See also 19990028721
Contract(s)/Grant(s): F49620-95-C-0050; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

Lynntech has developed a prototype of a new NDE/I probe for the detection of corrosion in aircraft metallic structures. The NDE/I system is based on electrochemical impedance (EI) measurements. Lynntech's EI prototype probe uses a single characteristic frequency of the ac signal applied between the probe and the structure under testing. At the selected frequency, the impedance signal is highly sensitive to the degree of corrosion of the sample under study. Thus, real time, on-line evaluation of the corrosion process has been easily achieved. The developed NDE/I probe is simple in design, portable, low in cost, and will not require trained personnel to operate. Another advantage of the probe design is that the use of aggressive electrolytes, a problem known in designing EI probes, is eliminated. The NDE/I probe has been fabricated in different sizes (from 2.3 to 182 sq cm), and is capable of detecting: (1) corroded areas as small as 5 x 10(exp -4) sq cm in painted surfaces, and, (2) a damage area/probe size ratio as low as 0.0004%. The probe has been successfully tested to promptly screen large areas of aircraft structures, such as fuselage, including lap joints and rivets.
Author
Nondestructive Tests; Impedance Measurement; Corrosion; Detection; Aircraft Structures; Structural Analysis

19990028759 NASA Langley Research Center, Hampton, VA USA
NASGRO 3.0: A Software for Analyzing Aging Aircraft
Mettu, S. R., Lockheed Martin Space Mission Systems and Services, USA; Shivakumar, V., Lockheed Martin Space Mission Systems and Services, USA; Beek, J. M., Lockheed Martin Space Mission Systems and Services, USA; Yeh, F., Lockheed Martin Space Mission Systems and Services, USA; Williams, L. C., Lockheed Martin Space Mission Systems and Services, USA; Forman, R. G., NASA Johnson Space Center, USA; McMahon, J. J., NASA Johnson Space Center, USA; Newman, J. C., Jr., NASA Langley Research Center, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 792-801; In English; See also 19990028721; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

Structural integrity analysis of aging aircraft is a critical necessity in view of the increasing numbers of such aircraft in general aviation, the airlines and the military. Efforts are in progress by NASA, the FAA and the DoD to focus attention on aging aircraft safety. The present paper describes the NASGRO software which is well-suited for effectively analyzing the behavior of defects that may be found in aging aircraft. The newly revised Version 3.0 has many features specifically implemented to suit the needs of the aircraft community. The fatigue crack growth computer program NASA/FLAGRO 2.0 was originally developed to analyze space hardware such as the Space Shuttle, the International Space Station and the associated payloads. Due to popular demand, the software was enhanced to suit the needs of the aircraft industry. Major improvements in Version 3.0 are the incorporation of the ability to read aircraft spectra of unlimited size, generation of common aircraft fatigue load blocks, and the incorporation of crack-growth models which include load-interaction effects such as retardation due to overloads and acceleration due to underloads. Five new crack-growth models, viz., generalized Willenborg, modified generalized Willenborg, constant closure model, Walker-Chang model and the deKoning-Newman strip-yield model, have been implemented. to facilitate easier input of geometry, material properties and load spectra, a Windows-style graphical user interface has been developed. Features to quickly change the input and rerun the problem as well as examine the output are incorporated. NASGRO has been organized into three modules, the crack-growth module being the primary one. The other two modules are the boundary element module and the material properties module. The boundary-element module provides the ability to model and analyze complex two-dimensional problems to obtain stresses and stress-intensity factors. The material properties module allows users to store and curve-fit fatigue-crack growth data. On-line help and documentation are provided for each of the modules. In addition to the popular PC windows version, a unix-based X-windows version of NASGRO is also available. A portable C++ class library called WxWindows was used to facilitate cross-platform availability of the software.
Author
Aircraft Structures; Applications Programs (Computers); Structural Analysis

19990028760 Portsmouth Univ., Portsmouth, UK

Automatic Analysis of Data Derived from Scanning Acoustic/Laser Doppler Velocimeter

Mew, Jackie, Portsmouth Univ., UK; Topp, Robert G., Portsmouth Univ., UK; Webster, John M., Holographics, Inc., USA; Thevar, Thangeval, Holographics, Inc., USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 802-810; In English; See also 19990028721

Contract(s)/Grant(s): DAAH01-95-C-R182; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

Large quantities of data are collected from a non-contacting acoustic/Doppler system that has been developed to non destructively inspect composite materials. It is time-consuming, exhausting and error-prone for a person to sit at a computer screen and physically browse up to 2048 detailed images that are produced from the data. Amongst those images only a small number contain useful information; the majority can be discarded. The useful images are easy to miss if the operator loses concentration, but vital as they may contain information about a fault. Computers process large quantities of information accurately without losing concentration or becoming fatigued. Expert evaluation of data derived from non-destructively inspecting composite samples such as those found on aircraft, ceramics, or metal structures such as helicopter blades, has led to the identification of rules, which in turn has led to the development of a prototype algorithm that automatically detects pertinent data and presents the shape of a fault as a two dimensional image. This paper reports on the results of tests on this prototype software, presenting the rules and applying them specifically to the identification of faults in composite structures. It concludes with a discussion of the next stage, which is the development of software to address issues raised from these experiments.

Author

Nondestructive Tests; Laser Doppler Velocimeters; Aircraft Structures; Fault Detection; Structural Analysis

19990028768 New South Wales Univ., School of Aerospace and Mechanical Engineering, Canberra, Australia

Modelling of Weak Bonds in Adhesively Fastened Joints

Shankar, Krishnakumar, New South Wales Univ., Australia; Fei, Dong, New South Wales Univ., Australia; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 875-884; In English; See also 19990028721; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

A new conceptual model for the analysis of peel behaviour of weakly bonded adhesive joints is presented in this paper. The paper focuses on modelling weakness in adhesion caused by deterioration of the adhesive bondline, as opposed to weakness in cohesion. For the purposes of analysis the bondline interface in a perfectly bonded adhesive joint is assumed to have the same material properties as the adhesive material, and modelled as such. The degradation of the bondline interface in a weak joint is modelled by considering reduced properties for the bondline interface. Finite element analysis of bonded doubler joints and double lap joints are carried out to study the peel deformation on the surface of the outer adherends. It is shown that when a doubler or a double lap joint has a good bond on one side and weak one on the other, the reduction in the strength of the bondline on the weak side causes an unsymmetric distribution of the load transferred by the outer adherends, resulting in bending. The bending deformation accentuates the peel deformation on one side while diminishing that on the other, resulting in a considerable difference in the distribution of out of plane displacements on the two sides. Measurement of the differences in the distribution of out of plane displacements using sensitive optical methods such as holographic interferometry enables the detection of weak adhesive bonds by non-destructive inspection.

Author

Bonded Joints; Lap Joints; Aircraft Structures; Structural Analysis; Bending; Load Distribution (Forces); Nondestructive Tests; Peeling

19990028770 Raytheon Systems Co., E-Systems, Waco, TX USA

Aircraft Corrosion Inspection and Evaluation Technique Using Scanning Ultrasonic Methods

Sivam, T. P., Raytheon Systems Co., USA; Ochoa, Carl M., Vista Engineering Services, Inc., USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 903-921; In English; See also 19990028721; No Copyright; Avail: CASI; A03, Hardcopy; A06, Microfiche

The present work is based upon the collection and evaluation of scanned ultrasonic data from corroded coupon test specimens. The ultimate purpose is to support an approach for a rating scale that can be used to monitor and evaluate quantitatively the effect of detected corrosion in aircraft upon service life for safety evaluation and for the planning of maintenance. Even though the results are preliminary, they indicate the utility of the methodology for aircraft maintenance purposes for some structural materials. For the present effort, representative structural thickness (.063 in.) of 2024 T3 aluminum coupons were corroded by exposure to sea salt water immersion as a simulation of aircraft skin corrosion. These coupons were subsequently examined using scanning ultrasonics and used to identify correlations between the corrosion mass loss and the residual strength and cyclic fatigue life of the coupons. The results indicate that for the corrosion mechanisms considered, it is likely that an accurate and useful field assessment

of corrosion may be made at the aircraft maintenance facility level, and that a rating scale is a realistic approach. The rating scale can be used in conjunction with ultrasound data collected from an aircraft and design and service history information to make projections of maintenance intervals and useful service life. Future efforts will address other structural materials such as 7075 T6 aluminum, and will focus upon quantifying intergranular effects in terms of their detection and their contribution to the structural degradation process during corrosion.
Author
Aircraft Maintenance; Aluminum Alloys; Corrosion; Service Life; Aircraft Structures; Ultrasonic Tests; Structural Analysis

19990028771 Northrop Grumman Corp., Hawthorne, CA USA
Aircraft Structural Integrity Monitoring System Development: Review of the Air Force/Navy Smart Metallic Structures Program
VanWay, Craig B., Northrop Grumman Corp., USA; Kudva, Jay N., Northrop Grumman Corp., USA; West, Mark N., Mission Research Corp., USA; Ziola, Steve M., Digital Wave Corp., USA; May, V. Scott, Air Force Research Lab., USA; Zeigler, Michael N., Air Force Research Lab., USA; Alper, James M., Naval Air Warfare Center, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 922-931; In English; See also 19990028721; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

Structural health monitoring (SHM) technologies, the concept of populating an airframe with an array of sensors for damage detection and loads monitoring, have the potential to revolutionize current methods of aircraft tracking. An automated health monitoring system capable of remote damage detection and comprehensive usage monitoring can significantly add to the established success of the US Air Force's aircraft structural integrity program (ASIP), and corresponding US Navy NASIP. Recent advances in sensing systems and data processing hardware have made it possible to greatly expand the type and amount of information used to assess the status of a structure. The objective of one recent investigation into structural health monitoring technologies, the joint Air Force/Navy Smart Metallic Structures (SMS) program, conducted by the Northrop Grumman Corporation, was to demonstrate a prototyped structural health monitoring system incorporating crack growth detection, strain recording, and integrity assessment. The recently concluded final test of this program, a full-scale fatigue test of a wing carry through bulkhead from a modern fighter aircraft, was conducted at the Air Force Research Laboratory, Wright Patterson Air Force Base (WPAFB) during April and May of 1997, and was successful in detecting fatigue crack growth and recording strain history in the bulkhead for the duration of the test. Eighteen acoustic emission sensors and twelve fiber optic strain sensors were distributed in five fatigue critical zones on the test article for health monitoring. Fatigue crack acoustic emissions were detected from a series of crack intitiations that eventually led to the catastrophic failure of the bulkhead on one of the critical zones. This paper will first present an overview of ASIP and its relationship to structural health monitoring (SHM), followed by a brief review of SHM requirements. The bulk of the paper consists of a review of the SMS program focusing on the health monitoring system architecture (specifically the sensors, processors, and analysis algorithms contained therein), the testing performed under the program, and the lessons learned. Health monitoring implementation payoffs are briefly discussed, and finally, conclusions and a preview of future programs are given.
Author
Systems Health Monitoring; Structural Failure; Structural Analysis; Fault Detection; Aircraft Structures; Sensors; Acoustic Emission; Fiber Optics

14
LIFE SCIENCES

Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and space biology.

19990032085 Norwegian Defence Research Establishment, Kjeller, Norway
Evaluation of Health Effects in Connection with a Change in Fuel Type from Diesel to F-34 ***Vurdering av Helsemessige Konsekvenser ved Overgang Fra Autodiesel Til Forsvarets Flydrivstoff (F-34)***
Arnt, Johnsen, Norwegian Defence Research Establishment, Norway; Tornes, John Aa, Norwegian Defence Research Establishment, Norway; Nov. 18, 1998; 64p; In Norwegian
Contract(s)/Grant(s): Proj. FFITOX/Oppdr-297001/138.
Report No.(s): FFI/RAPPORT-98/05899; ISBN 82-464-0309-5; No Copyright; Avail: CASI; A04, Hardcopy; A01, Microfiche

The consequences to human health and to the ecosystem connected with the substitution of diesel with F-34 jet fuel on ground vehicles have been evaluated. There are no indications that such a change will cause any enhanced health hazard or environmental hazard.
Author
Jet Engine Fuels; Health; Hazards

19990032524 Department of Energy, Assistant Secretary for Fossil Energy, Washington, DC USA
Task 8.6--Advanced Man Machine Interface (MMI)
Dec. 31, 1997; 13p; In English
Report No.(s): DE98-002021; DOE/MC/30246-5813; No Copyright; Avail: Department of Energy Information Bridge, Microfiche

The Solar/DOE ATS engine program seeks to improve the utilization of turbomachinery resources through the development of an Advanced Man Machine Interface (MMI). The program goals include timely and succinct feedback to the operations personnel to enhance their decision making process. As part of the Solar ATS Phase 2 technology development program, enabling technologies, including graphics environments, communications technology, and operating systems were explored to determine their viability to support the overall MMI requirements. This report discusses the research and prototyping effort, as well as the conclusions reached.
NTIS
Human-Computer Interface; Gas Turbines; ATS; Research and Development; Gas Turbine Engines

15
MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

19990032569 Institute for Computer Applications in Science and Engineering, Hampton, VA USA
Large-scale Parallel Unstructured Mesh Computations for 3D High-lift Analysis *Final Report*
Mavriplis, Dimitri J., Institute for Computer Applications in Science and Engineering, USA; Pirzadeh, S., NASA Langley Research Center, USA; February 1999; 24p; In English
Contract(s)/Grant(s): NAS1-97046; RTOP 505-90-52-01
Report No.(s): NASA/CR-1999-208999; NAS 1.26:208999; ICASE-99-9; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

A complete "geometry to drag-polar" analysis capability for the three-dimensional high-lift configurations is described. The approach is based on the use of unstructured meshes in order to enable rapid turnaround for complicated geometries that arise in high-lift configurations. Special attention is devoted to creating a capability for enabling analyses on highly resolved grids. Unstructured meshes of several million vertices are initially generated on a work-station, and subsequently refined on a supercomputer. The flow is solved on these refined meshes on large parallel computers using an unstructured agglomeration multigrid algorithm. Good prediction of lift and drag throughout the range of incidences is demonstrated on a transport take-off configuration using up to 24.7 million grid points. The feasibility of using this approach in a production environment on existing parallel machines is demonstrated, as well as the scalability of the solver on machines using up to 1450 processors.
Author
Parallel Computers; Unstructured Grids (Mathematics); Computational Grids; Aerodynamic Configurations; Supercomputers

16
PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

19990028361 United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT USA
Source Methodology for Turbofan Noise Prediction (SOURCE3D Technical Documentation) *Final Report*
Meyer, Harold D., United Technologies Corp., USA; Mar. 1999; 82p; In English
Contract(s)/Grant(s): NAS3-26618; RTOP 538-03-11

Report No.(s): NASA/CR-1998-208877; NAS 1.26:208877; E-11581; PWA-6420-104; No Copyright; Avail: CASI; A05, Hardcopy; A01, Microfiche

This report provides the analytical documentation for the SOURCE3D Rotor Wake/Stator Interaction Code. It derives the equations for the rotor scattering coefficients and stator source vector and scattering coefficients that are needed for use in the TFANS (Theoretical Fan Noise Design/Prediction System). SOURCE3D treats the rotor and stator as isolated source elements. TFANS uses this information, along with scattering coefficients for inlet and exit elements, and provides complete noise solutions for turbofan engines. SOURCE3D is composed of a collection of FORTRAN programs that have been obtained by extending the approach of the earlier V072 Rotor Wake/Stator Interaction Code. Similar to V072, it treats the rotor and stator as a collection of blades and vanes having zero thickness and camber contained in an infinite, hardwall annular duct. SOURCE3D adds important features to the V072 capability-a rotor element, swirl flow and vorticity waves, actuator disks for flow turning, and combined rotor/actuator disk and stator/actuator disk elements. These items allow reflections from the rotor, frequency scattering, and mode trapping, thus providing more complete noise predictions than previously. The code has been thoroughly verified through comparison with D.B. Hanson's CUP2D two- dimensional code using a narrow annulus test case.

Author

Applications Programs (Computers); Noise Prediction; Rotors; Stators; Turbofan Engines; Wakes; Rotor Aerodynamics; Documentation; Acoustic Simulation; Vorticity

19990028489 Old Dominion Univ., Dept. of Aerospace Engineering, Norfolk, VA USA

Subsonic and Supersonic Jet Noise Calculations Using PSE and DNS ***Final Report, Period ending 30 Sep. 1998***

Balakumar, P., Old Dominion Univ., USA; Owis, Farouk, Old Dominion Univ., USA; March 1999; 54p; In English; Original contains color illustrations

Contract(s)/Grant(s): NAG1-2054

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Noise radiated from a supersonic jet is computed using the Parabolized Stability Equations (PSE) method. The evolution of the instability waves inside the jet is computed using the PSE method and the noise radiated to the far field from these waves is calculated by solving the wave equation using the Fourier transform method. We performed the computations for a cold supersonic jet of Mach number 2.1 which is excited by disturbances with Strouhal numbers St=.2 and .4 and the azimuthal wavenumber m=l. Good agreement in the sound pressure level are observed between the computed and the measured (Troutt and McLaughlin 1980) results.

Author

Jet Aircraft Noise; Supersonic Jet Flow; Subsonic Flow; Stability; Far Fields; Wave Equations

19990028621 Boeing Commercial Airplane Co., Seattle, WA USA

Advanced Turbofan Duct Liner Concepts

Bielak, Gerald W., Boeing Commercial Airplane Co., USA; Premo, John W., Boeing Commercial Airplane Co., USA; Hersh, Alan S., Hersh Acoustical Engineering, Inc., USA; February 1999; 238p; In English; Original contains color illustrations

Contract(s)/Grant(s): NAS1-20090; RTOP 538-03-12-02

Report No.(s): NASA/CR-1999-209002; NAS 1.26:209002; No Copyright; Avail: CASI; A11, Hardcopy; A03, Microfiche

The Advanced Subsonic Technology Noise Reduction Program goal is to reduce aircraft noise by 10 EPNdB by the year 2000 relative, to 1992 technology. The improvement goal for nacelle attenuation is 25% relative to 1992 technology by 1997 and 50% by 2000. The Advanced Turbofan Duct Liner Concepts Task work by Boeing presented in this document was in support of these goals. The basis for the technical approach was a Boeing study conducted in 1993-94 under NASA/FAA contract NAS1-19349, Task 6, investigating broadband acoustic liner concepts. As a result of this work, it was recommended that linear double layer, linear and perforate triple layer, parallel element, and bulk absorber liners be further investigated to improve nacelle attenuations. NASA LaRC also suggested that "adaptive" liner concepts that would allow "in-situ" acoustic impedance control also be considered. As a result, bias flow and high-temperature liner concepts were also added to the investigation. The major conclusion from the above studies is that improvements in nacelle liner average acoustic impedance characteristics alone will not result in 25% increased nacelle noise reduction relative to 1992 technology. Nacelle design advancements currently being developed by Boeing are expected to add 20-40% more acoustic lining to hardwall regions in current inlets, which is predicted to result in and additional 40-80% attenuation improvement. Similar advancements are expected to allow 10-30% more acoustic lining in current fan ducts with 10-30% more attenuation expected. In addition, Boeing is currently developing a scarf inlet concept which is expected to give an additional 40-80% attenuation improvement for equivalent lining areas.

Author

Turbofan Engines; Aircraft Noise; Acoustic Ducts; Noise Reduction; Linings; Nacelles; Acoustic Attenuation

19990028654 Michigan Technological Univ., Houghton, MI USA
Signal Analysis of Helicopter Blade-Vortex-Interaction Acoustic Noise Data
Rogers, James C., Michigan Technological Univ., USA; Dai, Renshou, Michigan Technological Univ., USA; Mar. 20, 1998; 59p; In English
Contract(s)/Grant(s): NAG2-1095; No Copyright; Avail: CASI; A04, Hardcopy; A01, Microfiche

Blade-Vortex-Interaction (BVI) produces annoying high-intensity impulsive noise. NASA Ames collected several sets of BVI noise data during in-flight and wind tunnel tests. The goal of this work is to extract the essential features of the BVI signals from the in-flight data and examine the feasibility of extracting those features from BVI noise recorded inside a large wind tunnel. BVI noise generating mechanisms and BVI radiation patterns an are considered and a simple mathematical-physical model is presented. It allows the construction of simple synthetic BVI events that are comparable to free flight data. The boundary effects of the wind tunnel floor and ceiling are identified and more complex synthetic BVI events are constructed to account for features observed in the wind tunnel data. It is demonstrated that improved recording of BVI events can be attained by changing the geometry of the rotor hub, floor, ceiling and microphone. The Euclidean distance measure is used to align BVI events from each blade and improved BVI signals are obtained by time-domain averaging the aligned data. The differences between BVI events for individual blades are then apparent. Removal of wind tunnel background noise by optimal Wiener-filtering is shown to be effective provided representative noise-only data have been recorded. Elimination of wind tunnel reflections by cepstral and optimal filtering deconvolution is examined. It is seen that the cepstral method is not applicable but that a pragmatic optimal filtering approach gives encouraging results. Recommendations for further work include: altering measurement geometry, real-time data observation and evaluation, examining reflection signals (particularly those from the ceiling) and performing further analysis of expected BVI signals for flight conditions of interest so that microphone placement can be optimized for each condition.
Author
Blade-Vortex Interaction; Helicopters; Blade Slap Noise; Signal Analysis; Wind Tunnel Tests

19990032081 DYNACS Engineering Co., Inc., Brook Park, OH USA
Survey of Turbulence Models for the Computation of Turbulent Jet Flow and Noise ***Final Report***
Nallasamy, N., DYNACS Engineering Co., Inc., USA; March 1999; 40p; In English
Contract(s)/Grant(s): NAS3-98008; RTOP 538-03-11
Report No.(s): NASA/CR-1999-206592; NAS 1.26:206592; E-11568; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

The report presents an overview of jet noise computation utilizing the computational fluid dynamic solution of the turbulent jet flow field. The jet flow solution obtained with an appropriate turbulence model provides the turbulence characteristics needed for the computation of jet mixing noise. A brief account of turbulence models that are relevant for the jet noise computation is presented. The jet flow solutions that have been directly used to calculate jet noise are first reviewed. Then, the turbulent jet flow studies that compute the turbulence characteristics that may be used for noise calculations are summarized. In particular, flow solutions obtained with the k-e model, algebraic Reynolds stress model, and Reynolds stress transport equation model are reviewed. Since, the small scale jet mixing noise predictions can be improved by utilizing anisotropic turbulence characteristics, turbulence models that can provide the Reynolds stress components must now be considered for jet flow computations. In this regard, algebraic stress models and Reynolds stress transport models are good candidates. Reynolds stress transport models involve more modeling and computational effort and time compared to algebraic stress models. Hence, it is recommended that an algebraic Reynolds stress model (ASM) be implemented in flow solvers to compute the Reynolds stress components.
Author
Turbulence Models; Aerodynamic Noise; Computational Fluid Dynamics; Jet Aircraft Noise; Noise Prediction; Flow Distribution; Turbulent Jets

19990032087 United Technologies Research Center, East Hartford, CT USA
Development of a Linearized Unsteady Euler Analysis with Application to Wake/Blade-Row Interactions ***Final Report***
Verdon, Joseph M., United Technologies Research Center, USA; Montgomery, Matthew D., United Technologies Research Center, USA; Chuang, H. Andrew, United Technologies Research Center, USA; March 1999; 98p; In English
Contract(s)/Grant(s): NAS3-27727; RTOP 538-03-11
Report No.(s): NASA/CR-1999-208879; NAS 1.26:208879; E-11597; UTRC-R98-4.101.0255; No Copyright; Avail: CASI; A05, Hardcopy; A02, Microfiche

A three-dimensional, linearized, Euler analysis is being developed to provide a comprehensive and efficient unsteady aerodynamic analysis for predicting the aeroacoustic and aeroelastic responses of axial-flow turbomachinery blading. The mathematical models needed to describe nonlinear and linearized, inviscid, unsteady flows through a blade row operating within a cylindrical

annular duct are presented in this report. A numerical model for linearized inviscid unsteady flows, which couples a near-field, implicit, wave-split, finite volume analysis to far-field eigen analyses, is also described. The linearized aerodynamic and numerical models have been implemented into the three-dimensional unsteady flow code, LINFLUX. This code is applied herein to predict unsteady subsonic flows driven by wake or vortical excitations. The intent is to validate the LINFLUX analysis via numerical results for simple benchmark unsteady flows and to demonstrate this analysis via application to a realistic wake/blade-row interaction. Detailed numerical results for a three-dimensional version of the 10th Standard Cascade and a fan exit guide vane indicate that LINFLUX is becoming a reliable and useful unsteady aerodynamic prediction capability that can be applied, in the future, to assess the three-dimensional flow physics important to blade-row, aeroacoustic and aeroelastic responses.
Author
Unsteady Flow; Wakes; Euler Equations of Motion; Far Fields; Annular Ducts; Finite Volume Method; Design Analysis; Aerodynamic Characteristics

19990032207 NASA Langley Research Center, Hampton, VA USA
Two-Dimensional Fourier Transform Applied to Helicopter Flyover Noise
Santa Maria, Odilyn L., NASA Langley Research Center, USA; March 1999; 64p; In English
Contract(s)/Grant(s): NCCw-0076; RTOP 581-20-31-01
Report No.(s): NASA/TM-1999-209114; NAS 1.15:209114; L-17827; No Copyright; Avail: CASI; A04, Hardcopy; A01, Microfiche

A method to separate main rotor and tail rotor noise from a helicopter in flight is explored. Being the sum of two periodic signals of disproportionate, or incommensurate frequencies, helicopter noise is neither periodic nor stationary, but possibly harmonizable. The single Fourier transform divides signal energy into frequency bins of equal size. Incommensurate frequencies are therefore not adequately represented by any one chosen data block size. A two-dimensional Fourier analysis method is used to show helicopter noise as harmonizable. The two-dimensional spectral analysis method is first applied to simulated signals. This initial analysis gives an idea of the characteristics of the two-dimensional autocorrelations and spectra. Data from a helicopter flight test is analyzed in two dimensions. The test aircraft are a Boeing MD902 Explorer (no tail rotor) and a Sikorsky S-76 (4-bladed tail rotor). The results show that the main rotor and tail rotor signals can indeed be separated in the two-dimensional Fourier transform spectrum. The separation occurs along the diagonals associated with the frequencies of interest. These diagonals are individual spectra containing only information related to one particular frequency.
Author
Fourier Transformation; Aircraft Noise; Fourier Analysis; Aerodynamic Noise; Aeroacoustics; Helicopters

19990032564 NASA Lewis Research Center, Cleveland, OH USA
Supersonic Jet Noise Reductions Predicted With Increased Jet Spreading Rate
Dahl, Milo D., NASA Lewis Research Center, USA; Morris, Philip J., Pennsylvania State Univ., USA; Journal of Fluids Engineering; 1998; Volume 120, pp. 471-476; In English; Copyright; Avail: Issuing Activity, Hardcopy, Microfiche

In this paper, predictions are made of noise radiation from single, supersonic, axisymmetric jets. We examine the effects of changes in operating conditions and the effects of simulated enhanced mixing that would increase the spreading rate of jet shear layer on radiated noise levels. The radiated noise in the downstream direction is dominated by mixing noise and, at higher speeds, it is well described by the instability wave noise radiation model. Further analysis with the model shows a relationship between changes in spreading rate due to enhanced mixing and changes in the far field radiated peak noise levels. The calculations predict that enhanced jet spreading results in a reduction of the radiated peak noise level.
Author
Jet Aircraft Noise; Supersonic Jet Flow; Spreading; Electromagnetic Radiation; Far Fields; Gas Jets; Shear Layers

19990028751 F and S, Inc., Blacksburg, VA USA
Optical Fiber-Based Corrosion Sensors for Aging Aircraft
Elster, Jennifer L., F and S, Inc., USA; Greene, Jonathan A., F and S, Inc., USA; Jones, Mark E., F and S, Inc., USA; Bailey, Tim A., F and S, Inc., USA; Lenahan, Shannon M., F and S, Inc., USA; Perez, Ignacio, Naval Air Warfare Center, USA; The Second Joint NASA/FAA/DoD Conference on Aging Aircraft; January 1999, Pt. 2, pp. 716-721; In English; See also 19990028721
Contract(s)/Grant(s): N68335-97-C-0093; No Copyright; Avail: CASI; A02, Hardcopy; A06, Microfiche

Optical fiber corrosion sensors are being developed to address the high service costs associated with current structural maintenance procedures of civilian and military assets. A distributed optical fiber sensor system will help reduce the costs associated with corrosion damage and extend the lifetime of existing structures. Annual national losses in time, labor, materials and systems has been estimated in the billions of dollars. Additional costs arise from system downtime that results from disassembly procedures necessary to locate corrosion damage in remote locations. Furthermore, the potential to damage other system parts during maintenance is increased when disassembly and reassembly occurs. The development of on-line optical fiber sensors capable of detecting corrosion would eliminate a significant portion of the maintenance costs. We present recent test results using optical fiber long-period grating (LPG) corrosion sensors. With the appropriate coating, the sensors can be designed to detect moisture, pH, metal-ions, nitrides, or sulfides in otherwise inaccessible regions of the aircraft. The LPG sensors can be rendered immune to temperature cross-sensitivity, multiplexed along a single fiber, and can be demodulated using a simple, low-cost spectrum analyzer.

Author

Sensors; Optical Fibers; Aircraft Structures; Nondestructive Tests; Corrosion; Detection

19990032035 NASA Glenn Research Center, Cleveland, OH USA

Simultaneous Optical Measurements of Axial and Tangential Steady-State Blade Deflections

Kurkov, Anatole P., NASA Glenn Research Center, USA; Dhadwal, Harbans S., Integrated Fiber Optic Systems, Inc., USA; March 1999; 10p; In English; Turbo Expo '99, 7-10 Jun. 1999, Indianapolis, IN, USA; Sponsored by American Society of Mechanical Engineers, USA

Contract(s)/Grant(s): RTOP 538-03-11

Report No.(s): NASA/TM-1999-209051; NAS 1.15:209051; E-11587; No Copyright; Avail: CASI; A02, Hardcopy; A01, Microfiche

Currently, the majority of fiber-optic blade instrumentation is being designed and manufactured by aircraft-engine companies for their own use. The most commonly employed probe for optical blade deflection measurements is the spot probe. One of its characteristics is that the incident spot on a blade is not fixed relative to the blade, but changes depending on the blade deformation associated with centrifugal and aerodynamic loading. While there are geometrically more complicated optical probe designs in use by different engine companies, this paper offers an alternate solution derived from a probe-mount design feature that allows one to change the probe axial position until the incident spot contacts either a leading or a trailing edge. by tracing the axial position of either blade edge one is essentially extending the deflection measurement to two dimensions, axial and tangential. The blade deflection measurements were obtained during a wind tunnel test of a fan prototype.

Author

Optical Measurement; Aerodynamic Loads; Centrifugal Force; Wind Tunnel Tests; Fiber Optics; Turbomachinery

17
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Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law, political science, and space policy; and urban technology and transportation.

19990032117 Joint Advanced Distributed Simulation Joint Test Force, Albuquerque, NM USA

Collection and Analysis of Quality Data in a Distributed Simulation Test Environment

Gonzalez, Dean G.; Black, Jerry; Jan. 1998; 22p; In English

Report No.(s): AD-A359418; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

Since T&E using ADS is relatively new and continues to evolve, there are a paucity of tools available for general use that allow new T&E ADS personnel to evaluate the quality of their ADS system The quality focus of the tools presented is upon tools to assist in the detection of time errors, network-induced errors, and PDU-generation errors. Tools were developed that proved useful. These will be presented. The purpose of JADS testing is to assess the utility of ADS for T&E. This purpose is being accomplish through the execution of three distinctly separate tests. The first of these is called the System Integration Test (SIT). The first phase of this test is the Linked Simulators Phase (LSP). It is this first phase of the first test that has recently been completed and which is the basis for the tools presented. The SIT LsP tests simulate a shooter aircraft launching an air-to-air missile against a target aircraft. The shooter, target, and missile are represented by geographically separated simulators. The shooter is represented by the F/A-18 Weapon System Support Facility (WSSF) at China lake, CA. The missile is the AIM-9 Sidewinder Simulation laboratory (SIMLAB), also at China Lake, CA. The target is represented by the F-14 Weapons System Integration Center (WSIC) at Point Mugu, CA. Test control of this distributed test will be done from the Test Control and Analysis Center (TCAC) located at the JADS JTF in Albuquerque, NM. The SIT LsP test replicates a ”baseline” live fire test. The test evaluation method is to compare ADS test results with results from the identical ”baseline” test (This is a simplified view of the JADS testing... but it suffices for this discussion). Data collection and storage, the data analysis system, and time synchronization topics are reviewed as preparatory material for the presentation of the tools that have been developed.

DTIC

Data Acquisition; F-18 Aircraft; Air to Air Missiles; Data Simulation; F-14 Aircraft; Computerized Simulation; Systems Integration

Subject Term Index

A

B

C

D

E

F

G

H

I

J

K

L

M

N

Z

Personal Author Index

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